PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION.

APR 16 1923

Engineering Library

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2.

VOL. CXV.—No. 2987.] *LONDON: FRIDAY, MARCH 30, 1923.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 3½d.

Aveling & Porter, Ltd.,
ROCHESTER. 1108

Steam Road Rollers & Tractors.

A. G. Mumford, Ltd.
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches, BOILER FEED PUMPS.
See Advertisement, pages 24 and 25, last week.
PATENT WATER-TUBE BOILERS, AUTOMATIC FEED REGULATORS,
And Auxiliary Machinery as supplied to the Admiralty. 2179

For Sale, at Low Prices.
Three 60 inch Water-driven Hydro EXTRACTORS by Watson, Laidlaw & Co., Ltd.; new condition.
JOHN H. RIDDELL, LTD., 40, St. Enoch Square, Glasgow.

For Sale, Selections from
Stock at Reduced Prices.
Numerous AIR COMPRESSORS, Belt and Steam driven, from 10 ft. up to 2178 cubic feet.
MACHINE TOOLS of every Description. Shipyard Plant and Equipment a Speciality.
IF IT'S MACHINERY, SEND US YOUR ENQUIRIES.
JOHN H. RIDDELL, LTD., 40, St. Enoch Square, Glasgow. Established 1876. 592

SPECIFY WELDLESS STEEL CHAIN.
The Strongest Chain IN THE WORLD. 898
Sole Manufacturers: WELDLESS CHAINS, LTD., 50, WELLINGTON STREET, GLASGOW.

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 1133

Spencer-Hopwood & Kirke PATENT BOILERS. *See page 76, March 23.* 1293
Sole Makers: SPENCER BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

Æ Tubes, Plates, Rods, &c.,
in Brass and Copper.
ALLEN EVERITT & SONS, LTD.,
Kingston Metal Works,
SMETHWICK, BIRMINGHAM. 1344

Plenty and Son, LIMITED.
STATIONARY, STEAM AND MARINE ENGINEERS.
NEWBURY, ENGLAND. 1211

Steam Hammers (with or without guides). Hand-worked or self-acting TOOLS for SHIPBUILDERS & BOILERMAKERS. 1189
DAVIS & PRIMROSE, LIMITED, LEITH, EDINBURGH.

Penningtons, University
TUTORS, 364, Oxford Road, Manchester; Estab. 1876. Enrol now for L.C.E. and I.M.E. Postal Courses. 100 per cent. passes last Exams. Reinforced concrete—a new comprehensive course under expert engineer, £3 3s. Write for particulars. 968

Bever, Dorling & Co., Ltd.,
BRADFORD.
HIGH-CLASS ENGINES FOR ALL PURPOSES, also WINDING, HAULING, AIR COMPRESSING and PUMPING ENGINES. 1806

Cranes.—Electric, Steam,
HYDRAULIC and HAND, of all types and sizes.
GEORGE RUSSELL & CO., LTD., Motherwell, near Glasgow. 1137
Telegrams:—"Cylinders," Birmingham.

Weldless-Steel Tubes
for Water-tube Boilers, Superheaters, Heating, Hydraulic Work, Boring Rods, &c.
TUBES LIMITED, BIRMINGHAM. Od179

YARROW & CO. (1922), LTD., GLASGOW.
PASSENGER AND CARGO STEAMERS,
SHALLOW DRAFT VESSELS. 818

Campbells & Hunter, Ltd.
SPECIALISTS IN
Drillers & Boring Machinery
for Engine Works and Boiler Shops.
DOLPHIN FOUNDRY, LEEDS. 4547

Vosper & Co., Ltd.,
PORTSMOUTH.
SHIP & LAUNCH BUILDERS, Od 3551
ENGINEERS & BOILER MAKERS.

Cochran MULTITUBULAR AND CROSS-TUBE TYPES **Boilers.**
See page 17, March 23. 1134

The Mitchell Conveyor and TRANSPORTER CO., LTD.,
CONTRACTING ENGINEERS.
DESIGNERS and BUILDERS of all Classes of HANDLING MACHINERY.
Atlantic House, 45-50, Holborn Viaduct, London, E.C. 1.
Telegrams: "Mitchtrace, Cent, London."
Telephone: Holborn 2822. 967

The Glasgow Railway Engineering Company, GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 1234

Suitable for Light Railway, Tramway and General Power Transmission.
A complete GENERATING PLANT of 1000 Kw. capacity is available for immediate delivery, comprising two 500 Kw. high-speed, enclosed, Compound Engines and Dick-Kerr Dynamos, 500/550 Volts D.C., Allen's Surface Condensing Plant, Edwards' and other Pumps, Baker Separator, piping, valves, &c., complete. Very low price—excellent condition.
Also DIESEL ENGINES, 350/1300 HP.
JENNINGS, West Walls, Newcastle-on-Tyne. 978

P. & W. MacLellan, Ltd.,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 129, Trongate, Glasgow. Od 3547
Registered Offices: Clutha House, 10, Princes St., Westminster, S.W. 1.

Patent **See's** Hydro-Pneumatic **Ash Ejector.**
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. THEWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4335

Iron and Steel
Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 817
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 59.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM and GAS KETTLES, } Row's PATENTS.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

IRON & STEEL
Tubes AND Fittings AND Steel Plates.
STEWARTS AND LLOYDS, Ltd.
GLASGOW - BIRMINGHAM - LONDON.
See Advertisement Page 6. 1111

Drag Line Excavator.
Has moved 2,000 cube yards in one day. May be seen at Frodsham, near Chester. Reach 77 ft.; lift four to five tons; speed of working, one to three cuts a minute.
HARRY FAIRCLOUGH, Contractor, WARRINGTON. 1107

ON ADMIRALTY LIST.
John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL ST., E.C 3.
Works: BURNT MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice-making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c., &c. 846

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS, PRESSED STEEL WORK OF ALL KINDS.
Registered Office and Chief Works: Motherwell.
London Office: 14, Leadenhall Street, E.C. Od3382

THREE LANCASHIRE BOILERS, 30 ft. by 8 ft., reinsure 160 lbs. working pressure. New 1916.
TWO NEARLY NEW STEEL LANCASHIRE BOILERS, 30 ft. by 9 ft., reinsurable at 100 lbs. working steam pressure, complete with steam and furnace fittings, etc.
FIVE LANCASHIRE BOILERS, 30 ft. by 7 ft. 6 in., now insured at 150 lbs. pressure.
ONE LANCASHIRE BOILER, 30 ft. by 8 ft. 6 in., for 100 lbs. pressure.
COCHRAN VERTICAL BOILER, 16 ft. 3 in. by 7 ft. 6 in. diameter, reinsure 80 lbs. pressure.
TWO MARINE BOILERS, 10 ft. 4 in. by 12 ft. 2 in. diameter, reinsure 150 lbs. pressure.
NINE NEARLY NEW LOCO TYPE BOILERS, 10 N.H.P., reinsure 150 lbs. working pressure.
"GALLOWAY" BOILER, 24 ft. by 6 ft. 8 in. diameter, reinsure 100 lbs. pressure.
SEVERAL HUNDREDS OF TANKS, rectangular and circular, 10 gallons capacity upwards.
8000 GALVANISED STEEL WIRE ROPES, 360 ft. long by 1½ in. circumference.
CATALOGUE of Stock MACHINERY, 6000 Lots, Free on Application. Inspection Invited.
Thos. W. Ward, Ltd.,
ALBION WORKS, SHEFFIELD. 1005

Carels Diesel & Steam Engines. 1130
CARELS DIESEL & STEAM ENGINES (LONDON), LTD., Carlton House, Regent Street, London, S.W. 1. Telephone: Regent 3434.

YARROW & CO. (1922), LTD., GLASGOW.
LAND AND MARINE
YARROW BOILERS. 819

John Bellamy Limited,
MILLWALL, LONDON, E.
GENERAL CONSTRUCTIONAL ENGINEERS. 1216
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.,
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3383

Head, Wrightson & Co., LIMITED.
See Advertisement page 56, March 23. 2402

General Engineering
WORK PROMPTLY EXECUTED.
PARTS MACHINED AND ASSEMBLED.
Special work undertaken.
BRITISH VACUUM CLEANER AND ENGINEERING CO., LTD., Parson's Green Lane, Fulham, S.W. 6.

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED, DARLINGTON. 1312

GOLD MEDAL-INVENTIONS EXHIBITION-AWARDED
Duckham's Patent Suspended WEIGHING MACHINES—EAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD. LONDON, E.—Hydraulic Cranes, Grain Elevators, &c.
See illus. Advt. last week, page 15. 991

WAYGOOD-OTIS LIFTS 719
54 & 55, FETTER LANE, LONDON, E.C. 4.
69 & 83, LIONEL STREET, BIRMINGHAM, and Principal Provincial Cities and Abroad.

For Your Repairs or any SPECIAL MACHINERY, try—THOMAS HUNT & SONS, Albion Ironworks, Bridge Road West, Battersea, S.W. 11. Est. 1854. 1313

Petter Oil Engines.
For Paraffin and Crude Oil
Sizes 1½ B.HP. and upwards.
Petters Limited, Yeovil.
Sizes 25 to 500 B.HP.
Vickers-Petters, Ltd., Ipswich
See advertisement alternate weeks. 9335

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 999
See half-page Advertisement, page 68, March 16.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam, 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. H. STROMEYER, M.I.C.E.

Founded 1854 by Sir WILLIAM FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 1311

The Manchester Steam Users' ASSOCIATION.

The ANNUAL GENERAL MEETING of the Members was held in the Board Room of the Association, at their Offices, 9, Mount Street, Manchester, on Tuesday, March 20th, HAROLD LEE, Esq., J.P. (Manchester), President, in the Chair, when the following Resolutions were adopted:—

Moved by the CHAIRMAN, seconded by J. T. BROWNE, Esq., Pendlebury (Vice-President), and resolved:—

"That the Report of the Committee of Management to the Subscribers be adopted."

Moved by John Edward Taylor, Esq. (Messrs. Fletcher Burrows & Co., Ltd., Atherton), seconded by Edward Turnbull, Esq. (Messrs. Tate and Lyle, Ltd., Liverpool), and resolved:—

"That the thanks of the Association are due and are hereby presented to the Committee of Management for their past services, and that the following gentlemen be elected the Committee for the ensuing year, with power to add to their number":—

COMMITTEE OF MANAGEMENT.

HAROLD LEE, Esq., J.P., Manchester.
A. NORMAN DUGDALE, Esq., J.P., Blackburn.
JAS. STANLEY ADDISON, Esq., London.
J. T. BROWNE, Esq., Pendlebury.
ALFRED H. J. COCHRANE, Esq., Openshaw.
CHARLES W. CROSSLEY, Esq., J.P., Halifax.
CHARLES ROBERTS, Esq., Manchester.

Moved by George H. BURROWS, Esq. (Messrs. Pilkington Bros., Ltd., St. Helens), seconded by W. M. HEBBLETHWAITE, Esq. (The British Dyestuffs Corporation (Huddersfield) Ltd., Huddersfield), and resolved:—

"That Messrs. F. W. POPPLEWELL & SON, Chartered Accountants, Manchester, be appointed Auditors of the Association's Accounts for the year 1923."

JAMES PARR,
Secretary.

9, Mount Street, Albert Square, Manchester.
March 21st, 1923. A 13

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), and ALL ENGINEERING EXAMINATIONS personally conducted by Mr TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1296

A Brochure describing our

Special Course of training in the lucrative field of "ENGINEERING SALESMANSHIP and SALES MANAGEMENT" will be sent on application to DIRECTOR, THE INSTITUTE OF ENGINEERING SALESMANSHIP, 233, Oxford Rd., Manchester. 1119

Powering of Vessels. — A

Practical Course of Instruction by Correspondence.—Address, for particulars and terms, 1049, Offices of ENGINEERING.

TENDERS.

TO ENGINEERS AND SHIPBUILDERS.

THE CONSERVATORS OF THE RIVER THAMES invite

Tenders for the Construction

and DELIVERY afloat in the Thames at TEDDINGTON LOCK, MIDDLESEX, of a STEEL SINGLE SCREW (or alternatively twin-screw) STEAM RIVER TUG of the following overall dimensions for use on the upper Thames above Teddington:—

- Extreme dimensions, 58 ft. by 13 ft. 6 in. by 6 ft. 3 in.
- Draft, limited to 4 ft. 6 in. aft, and 4 ft. forward in working trim.
- Frames, 2½ in. by 2½ in. by ⅛ in., spaced 14 in./18in. apart with reverse frames, 2 in. by 2 in. by ⅜ in., plating ⅜ in. and ⅞ in., plate keel doubled.
- Bulwarks of ⅜ in. plate, 18 in. high to tumble in.
- Decks, ⅛ in. Chequered plate.
- Keelson and side keelsons of ample strength.
- Engines, Compound (or triple expansion) Surface Condensing, to develop at work at least 150 I.HP.
- Boiler, Marine 8 ft. by 8 ft., 150 w.p. to pass Board of Trade Special Survey.
- Trimming Tanks, fore and aft, and pump for filling and emptying.
- Propeller. Cast Steel, 4 ft. 6 in. diameter if single screw.
- All top hamper to pass under headway of 8 ft. 6 in. above water line, funnel to be made to lower.
- The whole to be of first-class British workmanship and British materials, complete with one cabin, storehouse and usual equipment and at least equal in all respects to Board of Trade and Lloyds regulations.
- Earliest date when delivery can be effected should be stated.

All enquiries should be addressed to the CHIEF ENGINEER at the undermentioned address.

Sealed Tenders marked "TENDER FOR TUG," accompanied by drawings and full specifications, and addressed to the Conservators of the River Thames, 2/3, Norfolk Street, Strand, London, W.C. 2, must be delivered not later than Ten a.m., on Monday, 23rd April, 1923. No Tender after that time will be considered.

The Conservators do not bind themselves to accept the lowest or any Tender.

F. W. GRARY,
Secretary.

Thames Conservancy Offices,
2/3, Norfolk Street,
Strand, London, W.C. 2.
20th March, 1923. X 963

MALTA.

Tenders are Invited for

the PURCHASE or LEASE of the DOCK, BUILDINGS, FITTINGS & MACHINERY, situated at Misida Creek, Malta, consisting of Hydraulic Lifting Dock, complete with pontoons and gear, necessary workshops, offices, etc., on shore, the whole to be disposed of as a Going Concern.

Particulars can be obtained from the Rear-Admiral, H.M. Dockyard, Malta, and the Civil Engineer-in-Chief, Admiralty.

All offers are to be delivered to the CIVIL ENGINEER-IN-CHIEF, ADMIRALTY, on or before 1st day of June, 1923. X 959

HUMBER CONSERVANCY BOARD.

TO SHIPBUILDERS.

Tenders are Invited for the

CONSTRUCTION and DELIVERY of a GAS FLOAT of the following dimensions:—length, 40 feet overall; breadth, 12 feet; depth, moulded, 5 feet 9 inches.

A copy of the Specification and Contract Drawing may be obtained from the undersigned on payment of £1 1s., which will be returned after receipt of a *bona fide* Tender.

Tenders should be enclosed in an envelope marked "Gas Float," and be delivered to the undersigned not later than the 21st April.

Tenders must specify a time for the completion of the work, and the successful tenderer will be required to enter into a contract with the Board.

The Board do not bind themselves to accept the lowest or any Tender.

ALFRED W. FRANKLIN,
Secretary.

Hull, 27th March, 1923. A 34

PORT OF LONDON AUTHORITY.

The Port of London Authority are prepared to receive

Tenders for Licences to Work

FOUR STEAM DREDGERS for raising ballast from the River Thames below Gravesend for a term of three years from the 1st August, 1923.

Copies of Instructions to Persons Tendering, Form of Tender, and the Conditions relating thereto, can be obtained on application to the Chief Engineer, Port of London Authority, Trinity Square, London, E.C. 3.

Tenders will be received until Noon on the 5th May, 1923.

The Authority do not bind themselves to accept the highest or any Tender, and reserve the right to grant any number of such Licences up to four, and any number of Licences to dredge sand, gravel, ballast, or other substances by hand power anywhere in the River Thames.

F. AYLIFFE,
Secretary.

Port of London Authority,
Trinity Square,
E.C. 3. A 21

APPOINTMENTS OPEN.

Wanted, First-class Machine

SHOP INSPECTOR, by large electrical manufacturers in the Midlands, one used to viewing and examining the larger machine parts of electrical machines. Only high grade men with experience in maintaining a high standard of machine shop practice need apply. State age, wages and experience.—Address, A 10, Offices of ENGINEERING.

Wanted for Railway in

Tropics, DISTRICT LOCOMOTIVE SUPERINTENDENT, thoroughly experienced, young, single, hard-working. Salary £500 per annum.—Write TROPICS, care of J. W. VICKERS & Co., LTD., 5, Nicholas Lane, E.C. 4. A 26

Works Manager Wanted, for

large Steel Works. Applicants must be practical, conversant with rolling mill practice (bars, billets, blooms, fishplates), and manufacture of Tyres, Axles, Cranks and other heavy forgings, for railway requirements. — Address, in confidence, giving details of career, age, qualifications and salary, A 46, Offices of ENGINEERING.

Wanted, a Manager for Small

Foundry, with technical and practical experience. Salary £300 a year, with bonus on profits. Ferrous and non-ferrous work.—Address, A 48, Offices of ENGINEERING.

THE TRUSTEES OF THE PORT OF KARACHI invite

Applications for the Post of

EXECUTIVE ENGINEER, from Civil Engineers, who have passed the examination for Associate Members of the Institution of Civil Engineers or hold an exempting degree, and who have had good experience on Dock Construction, preferably on a Contractor's Staff.

Salary, Rs. 600 per mensem, rising by annual increments of Rs. 50 per mensem for approved service to a maximum of Rs. 1200 per mensem.

The appointment will be probationary for six months. If confirmed, the applicant will be required to enter into a five years' agreement.

The successful candidate will be granted 1st Class Railway and Steamer fares to Karachi.

All officers of the Port Trust are required to join the Port Trust Provident Fund on confirmation, the deduction being 3-1/3 per cent. per mensem.

The Board contribute an equal amount and 5% per cent. interest is allowed on the whole. Leave and leave allowances will be given in accordance with the rules for the time being in force.

Applications, with copies of testimonials and full particulars of parentage, date and place of birth, educational and other qualifications, present employment and previous experience, to be addressed to:—

Messrs. RENDEL, PALMER & TRITTON,
12-14, Dartmouth Street,
Westminster,
London, S.W. 1.

so as to be received not later than the 27th April, 1923. A 37

The B.T.H. Co., Ltd.,

Chemical Dept., Rugby, have VACANCIES for CHEMIST APPRENTICES, of either sex. Applicants must have Matriculated (Chemistry essential) and be not under 16 or over 19 years of age. No premium required, salary paid, three years' indentured course with option of a fourth year. Only applicants who will take a University Degree Course after the Apprenticeship will be considered. Splendid opportunity to gain practical training in application of Chemistry and Metallurgy to Engineering.—Apply, giving full particulars, to THE SECRETARY OF APPRENTICESHIP COMMITTEE, THE BRITISH THOMSON-HOUSTON CO., LTD., Rugby. A 30

Engineer, to Take Charge of

Large Rolling Mill Plant; maintenance and construction. State age, qualifications and salary required.—Address, A 19, Offices of ENGINEERING.

Applicants for the Post of

Chief Assistant Engineer for Water Department of a large Company in London are thanked and are informed that the post has now been filled. A 12

Reinforced Concrete

DESIGNING ENGINEER REQUIRED immediately, having several years experience in the design of Reinforced Concrete structures. Written application with full particulars to PETER LIND & CO., 2, Central Buildings, Westminster, S.W. 1. A 28

Wanted.—Experienced

Chemical Works ENGINEER REQUIRED for a large Chemical Factory in the Midlands. Thoroughly acquainted with the design, construction and operation of all classes of chemical plant. Particulars of scientific training, with details of experience, copies of testimonials, salary required. —Address, X 971, Offices of ENGINEERING.

Wanted.—Several Engineer-

ing GRADUATES—preferably with an Engineering Degree—REQUIRED for training as Sectional Engineers in a large Chemical Factory in the Midlands. Good prospects for men with scientific knowledge, initiative and energy.—Address, X 972, Offices of ENGINEERING.

Civil Engineer Required for

Sudan. Salary £500 p.a. Age 23 to 27, single, robust. Must have had practical experience in levelling, surveying, setting out with theodolite and construction of buildings. State experience, training and references.—Write, "S.P. 26," c/o J. W. VICKERS & Co., Ltd., 5, Nicholas Lane, E.C. 4. A 40

Wanted, Engineer, Expert in

up-to-date wireless, including telephony and D.F. Well educated, possessing thorough training and extensive experience as Mechanical and Electrical Engineer and in I.C. engines and compressing plants. Draughtsman, used to design of mechanical and structural details. Age 29-31. Permanent pensionable appointment. Base rate for 2/3 years £350, equals £504 with present Civil Service Bonus, rising to base £500, equals £696 with Bonus. Bonus varies with cost of living. Civil Engineering experience not required, and amateur wireless no qualification.—Address, A 6, Offices of ENGINEERING.

H.M. SIGNAL SCHOOL, R.N. BARRACKS, PORTSMOUTH.

Applications are Invited

for TWO VACANCIES for ENGINEERS, Grade II., in the Laboratory Section of the above School. The duties concern the development of Wireless Telegraphy, etc., for Naval purposes. Preference given to candidates possessing an Honours Degree in Physics or Electrical Engineering.

The salary scale is £150, rising by annual increments of £10 to £300 per annum, plus bonus based on the average cost of living figure. The minimum pay plus bonus at present is £344 per annum.

The appointments are not established and the Federated Universities Superannuation Scheme is applicable.

Applications, giving full particulars of the candidate's experience, War Service, etc., should be addressed to "THE SECRETARY OF THE ADMIRALTY (C.E.), Admiralty, S.W.1," from whom further particulars of the duties, etc., can be obtained. X 902

MINISTRY OF TRANSPORT.

ROADS DEPARTMENT.

Applications are Invited

for a limited number of TEMPORARY APPOINTMENTS as ENGINEERS, in connection with new road construction works to be carried out in the vicinity of London. The appointments will carry inclusive Salaries at rates between £600 and £700 per annum, according to responsibility and qualifications.

Candidates should be Associate Members of the Institution of Civil Engineers, or should hold the testamur of the Municipal and County Engineers' Institution or some equivalent or higher professional qualification. Experience in road and bridge construction is essential. Candidates should not be more than 45 years of age and should have served in His Majesty's Forces.

Forms of Application can be obtained from the ESTABLISHMENT OFFICER, MINISTRY OF TRANSPORT, 6, Whitehall Gardens, S.W. 1. Applications can only be received on the recognised forms and should reach the Ministry of Transport on or before 9th April, 1923. A 41

Works Superintendent of

proved executive and organising ability for Electrical Switch and Control Gear Factory, South Midlands. Sound experience of modern production methods and processes essential. Electrical knowledge and experience of design an advantage. Fullest particulars in chronological order, with salary and age.—Address, A 86, Offices of ENGINEERING.

Engineer.—A Vacancy Occurs

for a well educated ENGINEER to take charge of the manufacture of Wireless Apparatus. Applicants must have first-class knowledge of latest manufacturing methods, and have held responsible positions previously on same or similar work. Permanent position for suitable man. Full particulars of experience, age, and salary required.—Address, A 44, Offices of ENGINEERING.

Assistant Engineer Required

for Nitrate Works in CHILE. Age 25 to 30. Salary £35 per month, with free board and residence. First-class passage out and home on completion of contract of Four years. Must be thoroughly good draughtsman, with good all-round knowledge of locomotives, distillers, pumps, electrical plant and structural work. Knowledge of Spanish an advantage.—Write, with testimonials (copies only), to O. A. B., c/o STREETS, 30, Cornhill, E.C. 3. A 23

Telegraph Operator Mechanic

REQUIRED, with experience in adjustment and working of quadruplex circuits and good all-round telegraph knowledge, including wiring and installing.—Address, giving details of experience and qualifications, stating salary required, A 58, Offices of ENGINEERING.

Electrical Instruments. —

WANTED, a first-class GENERAL FOREMAN to take charge of Department in Works in the North of England manufacturing electrical instruments, meters, telephones, and similar detail apparatus. Must have had experience in this class of work, able to control mixed staff of workpeople, and familiar with up-to-date methods of manufacture on an economical basis. State age, experience, qualifications, and salary required. Copies of recent references to be enclosed.—Address, A 45, Offices of ENGINEERING.

Engineering.—Working

FOREMAN WANTED for small constructional plant in Lincolnshire. Must have thorough knowledge of Planing, Boring, Turning and Fitting. State age and wages.—Address, A 33, Offices of ENGINEERING.

Wanted Immediately Railway

Signalling and Interlocking DRAUGHTSMAN. Knowledge of Electrical work desirable. —Address, with full particulars, age, and salary required, A 54, Offices of ENGINEERING.

Blueprinting.—Man Wanted

to take charge of Manufacturing Engineers' Blue Print Room and Drawing Files. Knowledge of Hall's Rotary Machines and Modern Blueprinting, Photostatic and Reproduction processes essential, together with experience of routine filing and card-indexing.—Address, stating age, experience, and salary required, X 927, Offices of ENGINEERING.

Draughtsmen, Electrical, for

A.C. and D.C. machines, for works in Midlands.—Address, stating age, experience, salary required, and when can commence, X 919, Offices of ENGINEERING.

Draughtsman Required for

North-East Coast, with experience of layout of Electricity Works Plant. Superficial knowledge only of electrical side required, but must have good experience of mechanical and steam practice. —Address, stating full particulars and salary, X 928, Offices of ENGINEERING.

Draughtsman Required, Ex-

perienced in Aerial Ropeways, Cranes, or similar work. State full particulars, experience, age, salary, etc. — Address, X 974, Offices of ENGINEERING.

Wanted, Senior Draughtsmen,

with first-class experience in the design of Aero Engines and high-class Motor Cars.—Address, giving full particulars of experience and salary required, A 14, Offices of ENGINEERING.

Machine Tool Draughtsman

for firm in the Manchester District. Must be widely experienced and capable of designing special Machine Tools. Intimate experience of many classes of Machine Tools essential; detailers need not apply. Good prospects for suitable man.—Address, A 29, Offices of ENGINEERING.

First - Class Draughtsman

Wanted by large Engineering Company in the Midlands; capable of designing Gas Plant and General Structural work. Good salary for the right man.—Address, stating age, salary expected, and experience, A 31, Offices of ENGINEERING.

Wanted Immediately Smart

JUNIOR DRAUGHTSMAN, used to Aircraft Work. State age, salary, when at liberty, and full particulars. Manchester District.—Address, A 43, Offices of ENGINEERING.

Draughtsmen Required with

good general civil engineering experience, capable of designing bridge and structural superstructures and foundations by latest scientific methods without detailed supervision. Permanency assured to suitable men—no others need apply. Must state experience fully and salary expected.—Apply by letter to DRAUGHTSMEN, Sir WILLIAM ARROL & COMPANY, Ltd., Dalmarnock Iron Works, Glasgow. A

THE GAS LIGHT & COKE COMPANY.

CHIEF DRAUGHTSMAN.

Chief Draughtsman Required

by the above Company. Candidates must have had first-class technical training and extensive experience in the design of buildings, structural steelwork, and plant for the mechanical handling of materials. A knowledge of the construction of Gasworks plant and river walls is also desirable.

Applications giving full information as to experience and qualifications, age, salary required, and endorsed "Chief Draughtsman," should be addressed to the CHIEF ENGINEER, THE GAS LIGHT & COKE COMPANY, Horseferry Road, London, S.W. 1, on or before 20th April. A

SITUATIONS WANTED.

Buyer.—The Manager of a

large Engineering Works Purchasing Department, who has an exceptionally wide knowledge of the markets of the Country, DESIRES to Negotiate NEW APPOINTMENT.—Write, Z.M., 613, care of DEACON'S, Leadenhall Street, E.C. 3. A

1923.

equired
Age 25 to 30.
nd residence.
ompletion of
oughly good
nowledge of
al plant and
anish an ad-
copies only).
S.C.3. A 23

echanic
adjustment
nd good all-
wiring and
experience
uired, A 56.

ents. —
RAL FORE-
Works in the
brical instru-
milar detail
in this class
workpeople,
manufacture
experience,
pies of recent
45, Offices of

Working
nstructional
rough know-
and Fitting.
3, Offices of

Railway
DRAUGHTS-
rk desirable,
, and salary

Wanted
ng Engineers
Knowledge of
Blueprinting,
ses essential.
ing and exci-
erience, and
NEERING.

ical, for
orks in Mid-
ence, salary
919, Offices

red for
ience of hy-
rficial know-
ut must have
am practice
and salary

red, Ex-
, Cranes, or
experience,
, Offices of

htsmen,
the design of
rs.—Address
and salary

ghtsman
strict. Must
of designing
ence of many
etailers need
table man.—

ghtsman
Company
as Plant and
for the right
pected, and
NG.

Smart
used to Ab-
liberty, and
ct.—Address

ed with
experience
tural supe-
st scientific
Permanency
need apply
expected.—
SIR WILLIAM
Iron Works
A 4

MPANY.

equired
es must have
d extensive
, structural
cal handling
nstruction of
desirable.
as to experi-
equired, and
be addressed
HERT & Co.,
.W.1, on
A 5

ED.

r of
ring Depart-
nowledge of
to Negotiate
613, care of
A 7

THE CENTENARY OF SIR WILLIAM SIEMENS.

ON Wednesday, April 4, occurs the centenary of the birth of Sir William Siemens, one of the brothers whose names are associated with the invention of the dynamo, the introduction of the regenerative furnace and its application to the steel industry and with the history of a great firm. Though of German birth, Siemens spent the greater part of his life in England and from 1859 was a naturalised Englishman. He was thus one of the many thousands of industrious and clever foreigners—such as Dolland, Herschel, Sprengel, Hurter, Mond and others who have so amply repaid the hospitality this country has shown them. Siemens early won for himself a distinguished position in British industrial and scientific circles, and his death in 1883 was regarded as a national loss.

Carl Wilhelm Siemens—to give him his original name—was born at Lenthe, in Hanover, and came of a long family. When his parents died in 1839 they had had no fewer than 14 children. The eldest son, Werner Siemens, was at that time but 23, but it was he who shepherded the family, and their success is a tribute to his foresight, energy and character. Of the sons who contributed to the fortunes of the family, first came Werner (1816–92), then Hans (1818–67), followed by Carl Wilhelm (1823–83), Friedrich (1826–1904) and Carl Heinrich (1829–1903). It is related of the French astronomers Paul and Prosper Henri, that so united was their friendship and collaboration that of their common work it is impossible to say what belonged to one and what to the other. It was the same with the Siemens brothers. They communicated freely, each placed his talents at the service of the others, the invention of one was often left to another to exploit, and in their dealings they displayed a frankness and freedom from jealousy perhaps unique.

When his father died Wilhelm, or William, was at a technical school at Magdeburg. From there he went to Göttingen University, where his brother-in-law Himly was professor of practical chemistry, and a year later, in 1842, returned to Magdeburg to enter the factory of Count Stollberg. It was while here he made his first invention—the chronometric governor. Werner at the same time was busy with a new electric process of gilding and silvering, and it was the attempt to place this upon the market that first brought William to England. His success on that occasion when, having been paid 1,600*l.* by Elkington of Birmingham, he was able to return home "a comparative Crœsus," led to a second visit. This took place in the spring of 1844, and from that time England became his home.

To follow Siemens through the next few years would only be to repeat a story common enough in the history of inventors. Neither his chronometric governor or the "anastatic process" of printing he had as his assets were taken up, and in 1846 he wrote to Werner "The governor affair lies dead. I am glad to get rid of it and will not worry myself about it any longer." Werner by now had turned to telegraph work, and in accordance with his advice William did the same. At the same time he secured various engagements in Lancashire, and while in the North he patented his "Improvements in engines to be worked by steam and other fluids." This was the so-called regenerative steam engine, and it was followed by a regenerative condenser and a regenerative evaporator. He had by now become known to many eminent engineers and men of science, and in 1850 he became the fully-accredited agent for Werner and his partner Johann Halske. Both Werner and William had exhibits at the Great Exhibition of 1851, and in 1852 William opened his first London office at 7, John-street, Adelphi. That same year he invented his water meter—the first profitable invention he had made—and from that time the tide of fortune turned in his favour.

The two fields in which Siemens did his most notable work were practical electricity and the application of heat to industrial processes. He was responsible for the planning of the works of Siemens Brothers at Charlton, in 1867 he published his important paper, "On the Conversion of Dynamical into Electrical Force without the aid of Permanent Magnetism" and in 1874 designed the well-known cable ship Faraday, which has laid some 50,000 miles of cable. A second Faraday has just been launched from Messrs. Palmer's yard at Jarrow. In the development of submarine telegraphy, the use of electricity for light and power, Siemens played an important part, and it was in his address to the Iron and Steel Institute in 1877 that he pointed to the possibility of utilising some of the power of the Niagara Falls and of transmitting it by electric conductors.

His work in heat, which began with his invention of the regenerative steam engine, was like John Elder's advocacy of the compound engine, one of the first fruits of the purely scientific discoveries of Joule, Mayer, Rankine and Kelvin. In 1853, Siemens read a paper to the Institution of Civil Engineers, "On the Conversion of Heat into Mechanical Effect." Here, says Sir Dugald Clerk, "for the first time we find the engineer guided by an intelligible principle." Of all the distinguished engineers who spoke on that occasion "Siemens alone had thoroughly apprehended the value of Joule's results." It was his knowledge of scientific principle that enabled Siemens to grasp the importance of the invention by Friedrich Siemens of the regenerative furnace. The invention was made in 1856, a year memorable in the history of industry as witnessing Bessemer's great discovery and Perkins' first work on the coal tar colours. Experiments made with the furnace were speedily followed by its practical application—notably at the glass works of Chance, in Birmingham—and in 1861 the two brothers patented their gas producer for use in conjunction with the regenerative furnace. The Siemens Sample Steel Works were started at Birmingham in 1866, and two years later the Landore Siemens Steel Company began work at Swansea. It was from here that Siemens, a few years later, supplied the material for the first of our steel-built men-of-war, H.M.SS. Iris and Mercury. This was the outcome of a challenge by Sir Nathaniel Barnaby to the steel makers of Britain to produce a steel reliable enough for shipbuilding. One result of the success of Siemens was that while in 1877 only 1 per cent. of our ships were built of steel, by the year Siemens had died, 1883, the proportion had risen to 14 per cent., and by the end of the century practically every ship was a steel ship. Coupled with the name of Siemens in this development is, of course, that of the French metallurgist Pierre Emile Martin, who was one of the earliest experimenters with a Siemens furnace and who, in 1865, patented the process of making steel in an open-hearth using pig-iron, scrap steel and iron oxide.

Of the personal history of Siemens little need be said. In 1859, the year he was naturalised, he married Anne Gordon the sister of Professor of Lewis Gordon, Rankine's predecessor at Glasgow, but had no children. He belonged to most of the great technical societies, was elected F.R.S., and served as president of the Society of Telegraph Engineers and the Institution of Mechanical Engineers. His services as a speaker and lecturer were as much sought after as were those of his greatest friend Sir Frederick Bramwell. He was knighted in April, 1883, and died the same year, on November 19, at the age of 60. A year or two later a stained glass window to his memory was unveiled in Westminster Abbey, close to the memorials of Joule, Kelvin, Brunel, Stephenson, Herschel and Newton.

THE NECHELLS POWER STATION OF THE BIRMINGHAM CORPORATION.

By W. NOBLE TWELVETREES, M.I.Mech.E., A.M.I.E.E., M.Soc.C.E.(France).

(*Continued from page* 356.)

Condensing Plant.—The condensing plant for the first two turbo-alternator sets was supplied and erected by Messrs. G. and J. Weir, Limited, of Cathcart, and is arranged in two sets, each comprising the following items: One Weir Uniflux surface condenser; one turbine-driven circulating pump and one Drysdale motor-driven centrifugal circulating pump, each designed for half duty; one turbine-driven water extraction pump and one Drysdale motor-driven water extraction pump, each designed for full duty; two steam jet air ejectors; one ejector heater; one direct-contact feed heater; one mild steel hot-well tank; one condensed water tank; one turbine-driven feed pump; two steam-driven direct-acting feed pumps; three evaporators and an untreated cold water tank, the evaporators and tank being common to both sets of condensing plant.

Each condenser is designed to deal with 198,000 lb. of steam per hour and to maintain a vacuum of 28 in. at overload, i.e., at an output of 18,000 kw., with the circulating water at an inlet temperature of 75 deg. F. Fig. 86, on page 386, shows diagrammatically the arrangement of the plants, this drawing having been made to illustrate the working of the scheme, a brief description of which is given below.

The condensate is drawn from the condenser by the turbine-driven extraction pump, or alternatively by the Drysdale motor-driven extraction pump, and is discharged first through the ejector heater, and then through the direct-contact heater to the hotwell tank. A Venturi meter on this line registers the rate of flow and the quantity of water passed. Air and any other non-condensable gases are drawn from the condenser by the steam jet air ejector, this being of the two-stage type, and discharged to the ejector heater where the heat is transmitted to the water discharged by the extraction pump, the heater draining to the cold water tank.

The direct contact heater is supplied with steam from the exhaust range into which the turbine-driven circulating pump and the turbine-driven extraction pump exhaust, and into which the vapour from the evaporator is led. In the event of the supply of exhaust steam being such that it causes the temperature of the hotwell to exceed 180 deg. F., the limit demanded by the economisers, the excess exhaust steam can be diverted to the condenser through a special balanced exhaust valve.

The hotwell tank contains two floats. One of these operates when the water level falls below normal working level and opens a valve admitting superheated steam to the evaporators, the vapour from which passes to the direct-contact heater where it is condensed, and then passes to the hotwell tank. The source of steam supply to the evaporators is a low-pressure stage of the main steam turbine. The second float operates in the event of the water level continuing to fall during the period when the evaporators are called into service and have not reached their normal output, or when the feed pumps are drawing more water than is being discharged by the extraction pumps. This second float opens a valve admitting water to the hot-well tank from the condensed water tank. The condensed water tank is also fitted with a float, so that when the water falls it opens a valve admitting saturated steam to the evaporators, and at the same time opens the valve supplying water to this tank through a calibrated diaphragm fitted in the extraction pump discharge range.

The evaporators make up the feed water as already described. The vapour from the evaporators can also be led to the condenser where the resulting condensate is afterwards dealt with by the extraction pump and returned to the tanks. The feed pumps draw directly from the hot-well tanks, or alternatively from the condensed water tanks.

Overhead Electric Crane.—The electric travelling crane in the engine-house was supplied by Messrs. Stothert and Pitt, Limited, of Bath. It has a span of 62 ft. 2¼ in., the height of lift being 48 ft. for the main lift of 100 tons and 50 ft. for the auxiliary lift of 25 tons, the corresponding hoisting speeds being 3 ft. and 12 ft. per minute, respectively.

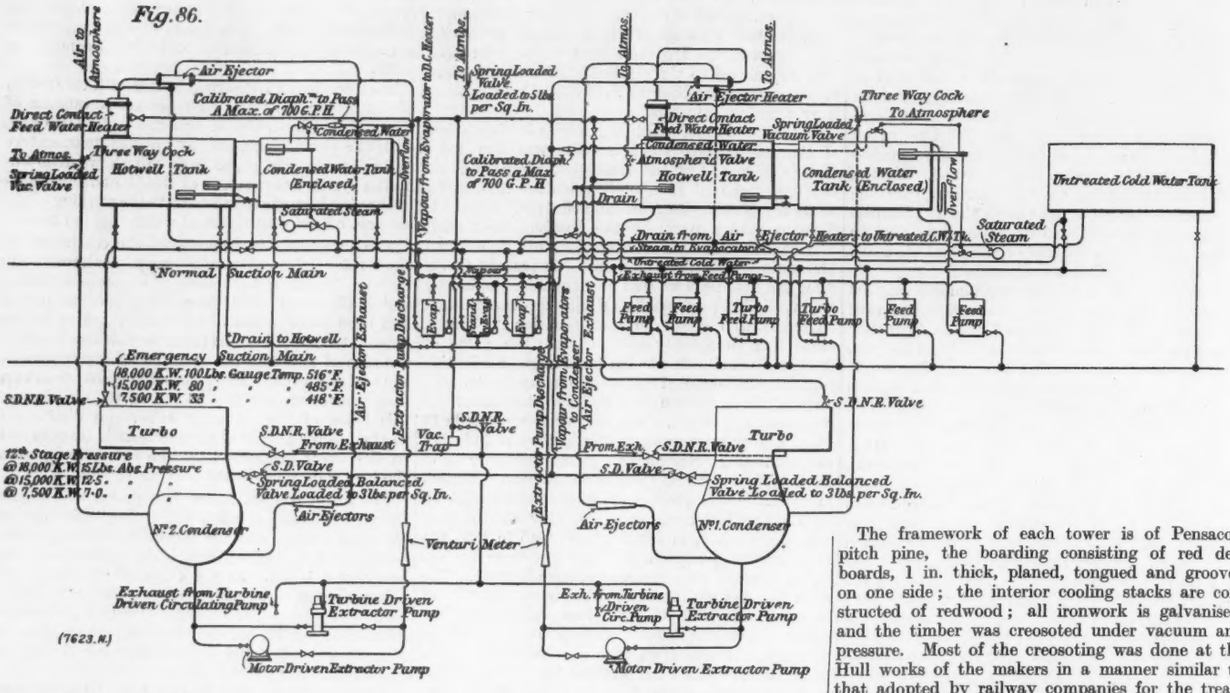
Water Cooling Plant.—A general description has already been given of the reinforced concrete cooling ponds in the immediate vicinity of the power-house. The ponds, the cooling towers by which they are surmounted, the suction and discharge mains and the surface condensers connected with the ponds by these mains, constitute a system through which water is continuously circulated by means of the electrically-driven circulation pumps, being reduced in temperature from 92 deg. to 75 deg. F. in the cooling towers.

When the ponds have once been filled, the only

THE NECHELLS POWER STATION OF THE BIRMINGHAM CORPORATION.

MR. R. A. CHATTOCK, M.I.E.E., CITY ELECTRICAL ENGINEER.

Fig. 86.


Air to Atmosphere
Air Ejector
Calibrated Diaph.™ to Pass A Max. of 700 G.P.H.
Direct Contact Feed Water Heater
Condensed Water
To Atmos.
Three Way Cock
Spring Loaded Vac. Valve
Hotwell Tank
Condensed Water Tank (Enclosed)
Overflow
Vapour from Evaporator to D.C. Heater
To Atmos.
Spring Loaded Valve Loaded to 5 lbs. per Sq. In.
Calibrated Diaph. to Pass a Max. of 700 G.P.H.
Saturated Steam
Normal Suction Main
Drain to Hotwell
Emergency Suction Main
(18,000 K.W. 100 Lbs. Gauge Temp. 516° F
15,000 K.W. 80 " " 485° F
7,500 K.W. 33 " " 418° F
S.D.N.R. Valve
Turbo
12½ Stage Pressure
@ 18,000 K.W. 15 Lbs. Abs. Pressure
@ 15,000 K.W. 12·5 "
@ 7,500 K.W. 7·0 "
S.D.N.R. Valve From Exhaust
S.D. Valve
Spring Loaded Balanced Valve Loaded to 3 lbs. per Sq. In.
Air Ejectors
No. 2 Condenser
Air Ejector Exhaust
Extractor Pump Discharge
Vac. Trap
S.D.N.R. Valve
Vapour from Evaporators to Condenser
Air Ejector Heater
Direct Contact Feed Water Heater
Spring Loaded Vacuum Valve
Three Way Cock To Atmosphere
Atmospheric Valve
Drain
Drain from Air Ejector Heater to Untreated C.W. Tk.
Untreated Cold Water Tank
Saturated Steam
Exhaust from Feed Pumps
Feed Pump
Turbo Feed Pump
S.D.N.R. Valve
From Exh.
Spring Loaded Balanced Valve Loaded to 3 lbs. per Sq. In.
Air Ejectors
No. 1 Condenser
Venturi Meter
Exhaust from Turbine Driven Circulating Pump
Turbine Driven Extractor Pump
Exh. from Turbine Driven Circ. Pump
(7623. N.)
Motor Driven Extractor Pump

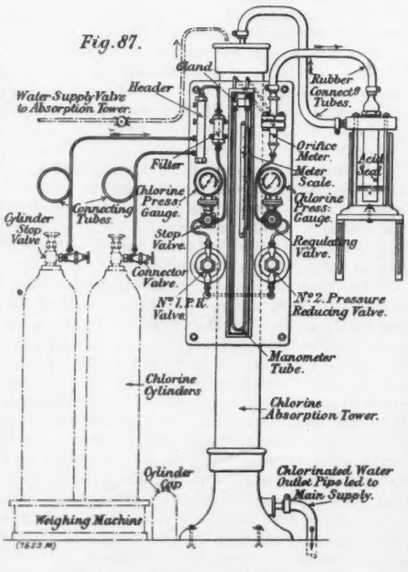
make-up water to be provided is that necessary to compensate for evaporation and other losses. Water for this purpose is fortunately available in the form of purified sewage effluent from the filter beds adjacent to the cooling-pond site. Some 3,000,000 gallons of effluent were formerly discharged daily into the River Tame, the effluent now being used in the water-cooling system, after treatment in the chlorinating plant in front of the ponds.

The utilisation of this effluent was first made in the temporary generating station, where it has proved to be eminently suitable for condensing purposes, the water being very soft and slightly alkaline. It therefore tends to keep the condenser tubes clean and to prevent the formation of scale. No objectionable odour can be detected, and the effective aeration of the water in the towers naturally has a purifying effect. As an additional precaution the effluent is passed through the chlorinating plant described later, and after sterilisation by chlorine gas it is discharged into the suction culverts.

The suction mains between the ponds and the engine-house are 36 in. in internal diameter and pass along the culvert shown in the cross-section of the power-house, given in Fig. 1, published on page 100, of our issue of January 26. The discharge branches from the condensers are of 36 in. internal diameter, discharging into 48 in. diameter mains, and passing overhead to the cooling stacks of the towers. Suitable interconnections are made so that either of the circulating pumps may draw water from or discharge it to any of the ponds in case of need. The contract for the suction and discharge pipe work and valves connecting the cooling towers with the condensers was let to Messrs. E. E. Jeavons and Co., Limited.

Cooling Towers.—The first contract for cooling towers was placed with the Davenport Engineering Company, Limited, of Bradford, and covers the supply and erection of 17 natural draught chimney type towers, capable of dealing with 2,877,500 gallons of water per hour, reducing the temperature of the water from 92 deg. to 75 deg. F., with the atmosphere at 55 deg. F., and possessing 80 per cent. of humidity. When the scheme has been fully carried out there will be no fewer than 41 towers, capable of cooling nearly 7,000,000 gallons of water per hour. The towers at present erected are in four groups, over the corresponding reinforced concrete ponds, and the general dimensions of the towers are as follow :—

Fig. 87.



Group.	Length of Group.	Width of Towers.	Height of Towers.
	ft. in.	ft. in.	ft. in.
(1) 4 Towers.. ..	268 6	24 0	106 0
(2) 3 Towers.. ..	339 6	24 0	106 0
(3) 5 Towers.. ..	429 0	24 0	106 0
(4) 5 Towers.. ..	440 10	24 0	106 0

The towers are arranged end to end, the individual towers measuring 89 ft. 6 in. in length, with the exception of the end tower in each group, where the length has been reduced to suit the length of the corresponding pond. The condenser water inlet to each tower is at a height of 18 ft. 6 in. above the top of the foundations.

The framework of each tower is of Pensacola pitch pine, the boarding consisting of red deal boards, 1 in. thick, planed, tongued and grooved on one side; the interior cooling stacks are constructed of redwood; all ironwork is galvanised, and the timber was creosoted under vacuum and pressure. Most of the creosoting was done at the Hull works of the makers in a manner similar to that adopted by railway companies for the treatment of sleepers.

The cooling stacks are quite independent of the chimney portion of the tower and are supported directly by reinforced concrete beams at the top of the foundations. Each cooling stack consists of a framework of upright guide posts holding in position a number of side bearers which are V-notched by machine on both edges, the notches on the top edge being between those on the bottom edge. The laths are of square cross-section, and when fixed in position the diamond points are uppermost, and the laths are spaced at regular intervals both horizontally and vertically throughout the length of the cooling stack. The method of fixing makes it impossible for the bearers or laths to be out of position, while they are sufficiently free to allow for expansion.

The system of water distribution is probably the most interesting feature of the towers. It was the practice of the makers, at one time, to arrange the water distribution with the usual open-type troughs, tubes and splash plates. This system was attended with the disadvantage that if any sediment was deposited either in or around the tubes, the flow of water was seriously diminished or deflected. Another disadvantage was that the open troughs were apt to become coated by deposits of silt, and to suffer diminution of carrying capacity.

The system of distribution now adopted by the firm is effected by means of one main trough of large capacity for each tower, two intermediate troughs and a large number of small distributing troughs, the latter being fed by wooden down pipes from the intermediate troughs. The distributing troughs are entirely enclosed and have brass discharge tubes fitted in the top at regular intervals, a patent metal sprayer being fitted at the top of each tube. The sprayer, in the form of a stepped cone, having its smaller end below and being arranged directly over, and at a fixed distance from, the top of the discharge tube, causes the upward jet of water to be effectively sprayed over the cooling stack, the height to which the spray rises being governed by the head of water due to the level at which the intermediate troughs are fixed. Any sediment deposited from the water settles in the small distributing troughs, these being provided with sluices at each end so that the sediment which is kept in a state of suspension owing

THE NECHELLS POWER STATION OF THE BIRMINGHAM CORPORATION.

MR. R. A. CHATTOCK, M.I.E.E., CITY ELECTRICAL ENGINEER.

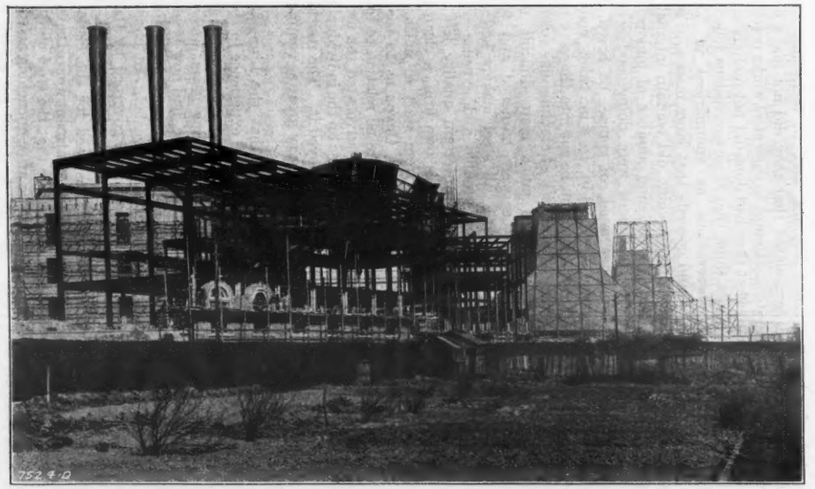


FIG. 88. SWITCH-HOUSE DURING ERECTION WITH COOLING TOWERS IN BACKGROUND.

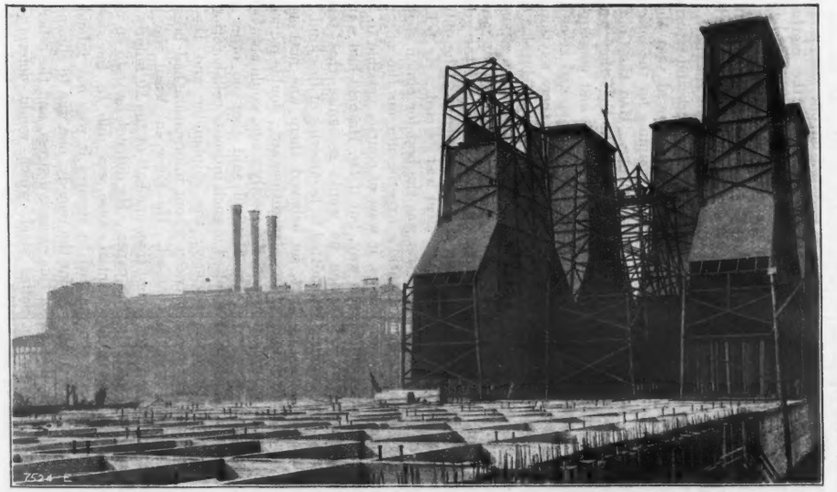


FIG. 89. COOLING TOWER FOUNDATIONS AND TOWERS DURING ERECTION.

FIG. 90. COOLING TOWER FOUNDATIONS AND TOWERS DURING ERECTION.

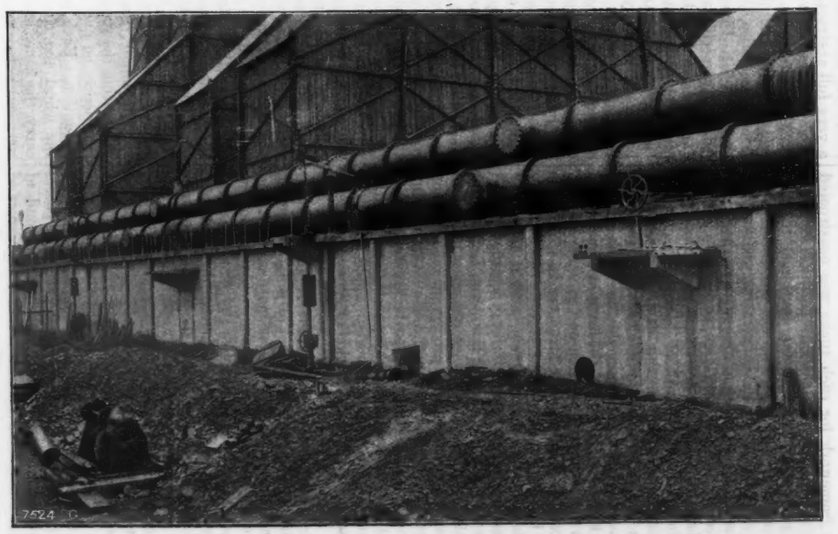


FIG. 91. VIEW OF BASE OF TOWERS SHOWING SUCTION AND DISCHARGE MAINS.

to the absence of air, can be washed out when desired.

The framework for each tower was constructed before delivery, and the whole of the timber for other parts was also cut and machined to sizes before delivery. Various views of the towers have already been given in connection with earlier sections of this description, and some further views are given in Figs. 88 to 91, on page 387. Fig. 88 is a distant view of the towers nearing completion, and shows the framework of the switch-house in the foreground. Figs. 89 and 90 show views of the towers during erection, and clearly illustrate the columns and bearings forming the tower foundations, while Fig. 91 is a view of the base of some of the towers and shows the suction and discharge mains.

Chlorinating Plant.—The structure in which this plant is accommodated has already been briefly described in an earlier section, and it now only remains to give particulars of the apparatus installed by the Paterson Engineering Company, Limited, for the chlorination of the sewage effluent supplied to the cooling ponds. The process of chlorination involves nothing more than the admixture of pure chlorine gas with the water to be treated, and if desired the addition of a dechlorinating agent to the effluent. Chlorine was formerly applied for the purpose in the form of chloride of lime, the use of which involved variable results, as well as the handling and preparation of the reagent in considerable bulk and the disposal of a corresponding large amount of sludge. A far more efficient and economical method is to employ chlorine in the gaseous state, as provided for by the apparatus introduced by the Paterson Engineering Company.

Fig. 87, on page 386, shows the essential features of the Manometer type of this apparatus. The gas cylinders are arranged in three groups of six, two groups mounted on weighing machines for checking consumption, and the third group as a stand-by. Gas is led to the manometer board through copper tubes, first entering a filter and then passing through a chlorine pressure gauge. The gas next passes through two reducing valves from the second of which it emerges at a constant delivery pressure of 10 lb. per square inch. The gas then flows in succession through a regulating valve, a second pressure gauge and a meter indicating the exact flow of gas in pounds per hour. As chlorine gas when moist has a strongly corrosive effect on metals, it is necessary to isolate the measuring instrument from the water side of the apparatus. This end is attained by an acid seal, wherein the dry gas bubbles through sulphuric acid, the arrangement of this seal being shown at the right hand of the figure. After leaving the acid seal the gas is discharged through a vertical central pipe to the lower part of a glazed vessel termed the chlorine absorption tower. The tower is fitted at the top with a water distribution tray packed with pumice stone, over which water trickles absorbing the measured volume of chlorine in its downward course. The chlorine water flows from the bottom of the tower through india rubber piping and is uniformly distributed throughout the main body of the water to be treated as the latter enters the contact tank. As before stated, the reinforced concrete contact tank measures 48 ft. by 24 ft. by 15 ft., its size being sufficient to permit the water to be in contact with the chlorine for over an hour. The tank has a central division wall and a number of baffle walls to ensure thorough mixing and to help in keeping the whole volume slowly on the move. After passing through the tank, the water is led up through three small compartments where a dechlorinating agent can be added if found desirable.

(*To be continued.*)

THE INSTITUTION OF NAVAL ARCHITECTS.

(*Continued from page* 374.)

As on the previous day, the chair at the meeting last Thursday morning was occupied by the President, His Grace the Duke of Northumberland.

GEARING TROUBLES AND THEIR REMEDY.

Only one paper was taken at the morning sitting. This dealt with "Mechanical Gearing," and had for its authors Sir Charles A. Parsons, F.R.S., Mr. S. S. Cook and Mr. H. M. Duncan. We reproduce a very full abstract of it on page 408.

The discussion was opened by Vice-Admiral Sir G. Goodwin, who, after referring to the great assistance the Admiralty had received in the past from Sir Charles Parsons, and to the help given them by Mr. Duncan in the preparation of the Admiralty specifications for pinion steel, said many explanations had been proferred as to the comparatively numerous failures of reduction gears in the mercantile marine. The Admiralty had not had nearly so many, yet, nevertheless, it had been thought useful to try and apply to their own experiences the various theories brought forward as to why trouble had occurred. As a result, he did not believe that any one of these theories or any combination of them was sufficient to account for the actual facts of observation. The Leonidas was the first naval ship to be fitted with gearing, and there was a serious breakdown. Both the pinion that failed and its fellow were brought on shore, and in the former were found serious cracks at the roots of the teeth, which he believed were there at the start. The difference in quality between this pinion and its fellow was most striking. The experiments and observations then made convinced most of those concerned either that the metal was cracked originally or was not homogeneous, and suffered from internal stresses. The matter was gone into vigorously but quietly; as a result, alterations were made. Some were of a mechanical nature, in which he had to acknowledge the help received from the authors' firm, and for the rest a provisional specification was compiled for the guidance of the metallurgist, but this was not enforced for some time as they did not feel sure of their ground. So far as the Navy was concerned, they had been very fortunate, the mishaps being very few. In contrasting the theories brought forward with naval experience, he had been much helped by one consideration. Each gear consisted of two elements, the wheel and the pinion, both of which had to carry the same load and to a first approximation were subjected to equal stresses. Want of alignment, torsional oscillations and shocks would affect both wheel and pinion teeth equally. Yet it was the pinion, which was constructed of what was nominally a much superior material, which failed. In the case of the Leonidas he was satisfied that the fault lay with the material, which was either not uniform to start with or had had its properties destroyed by the heat treatment. In the last page of their paper the authors had laid stress upon great accuracy in the cutting and alignment of the teeth. For his own part, he hoped that the ultimate solution of the problem would render this unnecessary, though it must be insisted on for the present. It was very difficult and very costly to maintain a very high degree of accuracy in machinery in service, and he hoped that ultimately it would be found possible to dispense with this.

Mr. Rutyen, who followed, said that, in proposing that oil quenching should be discontinued, the authors, he concluded, did not approve of the specification agreed to last July. Lloyds' had issued this specification to their surveyors, but had made it clear that it was not compulsory, their opinion being that the matter was best dealt with by the manufacturers and not by a classification society. From Commander Tostevin's paper it appeared that out of 596 gears in the Navy, only six had given trouble. The Admiralty practice since 1921 had been, he believed, to have the pinion bored out hollow, and, after rough machining, it was heat-treated and quenched in oil. Solid pinion shafts were used in the mercantile marine, but he was at a loss to understand why the record had not been as good as in the Navy. If oil quenching were to be abandoned, what steel should be used? Steel makers asserted that the best qualities of their nickel steels were only developed by heat treatment. Some troubles, no doubt, had been due to lack of accuracy, and he was glad to hear that the author's firm were aiming at a still higher standard in this regard.

Captain Onyon, who spoke next, said that last year he had described the breakage of a pinion tooth on the Conte Rosso. This had been replaced with a pinion of Beardmore's D.R. steel, and subsequently the ship ran for six months, crossing the Atlantic at a speed of 18½ knots. At the end of this time noise was reported on one side, and he had gone to Naples to look into the matter. He found that there was a lot of noise, and he had to decide whether the vessel should be allowed to sail, and decided that she might. As she left the harbour one of her propellers struck the harbour wall and thus loosened the wheels on the shaft. Nevertheless, the ship went to New York and returned at a speed of 18½ knots. He believed that the proposal to insert a flexible coupling for the intermediate gears was a mistaken one. Had the Conte Rosso been thus fitted, he thought that they would have had trouble from slackness, and consequent wear and noise. The pinions of special steel had stood up to the work, and were there anything wrong with oil-treated teeth, he thought breakages would have occurred under the very severe strains. At Genoa the gears had been opened up and the wheels tightened on their shaft, and the gears were now running absolutely quietly. The only objection to the D.R. steel was its cost. He believed that the Izod test was the best for pinion steel. As for Dr. Hatfield's experiments on the effect of repeated blows, it was, of course, possible to break steel in this way, but if Dr. Hatfield had watched gears in action he would recognise that teeth were not submitted to hammering of this kind. For his own part, he believed there was nothing wrong with plain straightforward double-reduction gearing, which, if correctly made, would always be successful.

Dr. Hatfield said that no other problem had resulted in such intimate collaboration between the engineer, the shipbuilder and the metallurgist, between whom information had been freely interchanged. He knew in detail the particulars of more than one-half of the 20 failures referred to in the paper. He did not hesitate to claim that the essential cause was due to the steel being submitted to stresses it was not intended to stand. As for the remedy, one was to eliminate the causes of this excessive stress, and the other was to use a softer steel, which would deform more readily. The authors, he considered, had confused the issue by comparing cracked steel with soft steel. He did not think the authors were qualified to harden steel forgings, and, in fact, they might be congratulated that they did not make more cracks in their attempt to copy steel works practice. Actually what they had done did not reproduce this. He did not think that their conclusions followed from their observations as summarised in Table II. He would concede that large masses of steel subjected to oil quenching did contain internal stresses, but an overwhelming number of pinions submitted to this treatment were doing good service. Heavy forgings must, of course, be bored, but a nickel steel sleeve, 3 in. to 4 in. thick, could, by proper heat treatment, be got into the very best condition, and with no risk of cracking like solid forgings. In short, steels much more difficult to treat than pinion steels were hardened and tempered with full success. All steel makers had gone to very considerable trouble and expense to ensure that no pinion of uncertain quality left their works. In the case of his own firm, a clean bill of health could be given from start to finish. He did not agree with Captain Onyon as to the value of the Izod test, which bore no relation to tooth fractures. Sir Charles Parsons advocated the use of soft steel, but this must be done on the individual responsibility of those who employed it. The resistance of nickel steel to wear was very great as compared with mild steel.

Mr. Wiborg said that the Ljungström Company had had considerable experience in the use of steel, both for land and marine gears. In the latter they fitted epicyclic reversing gears, and the first ship so fitted, the ss. Pacific, had now been in service for three years and had steamed 110,000 miles without any defect being revealed. In choosing steel for gears they had been governed by their experience with turbine rotors, where a high tensile heat-treated steel was used for the blade rings. Both composition and treatment were of equal importance. It was imperative that the steel used should not be hard and brittle after quenching and before tempering. The carbon should not exceed 0·3 per cent., even if the nickel were as low as 3 per cent., and if

higher nickel were to be used the percentage of carbon must be reduced. His firm had had only one case of a defective pinion, and here analysis showed that the composition did not comply with the specification. As regards mechanical questions, the gear case should have a very small area of contact with the ship's structure, so that the elastic deformation of the latter would not greatly affect the alignment. The base should, in short, be only large enough to deal with the torque transmitted by the shaft. The casing, on the other hand, should be as stiff as possible. With the precaution described, rigid gears were quite as good as floating frame gears.

Dr. J. H. Smith agreed with Dr. Hatfield that the hardening of steel was not a matter for engineers to tackle. He believed that hard steels were necessary in teeth to prevent vibration from wear, and that the solution of gear troubles was to be found in avoiding critical speeds. If hardening were dropped, other troubles would crop up. He did not agree with the authors that there was as much trouble with single as with double-reduction gears. If the first were bad, the second were very bad. Last year he had discussed the nodal drive as fitted to one small ship. It had now been applied to 120,000 s.h.p. Including blade strips, he had records of 40 failures of geared ships last year. He had investigated a number of strips and had concluded that they were all connected with one or other of the periodicities of the turbine shaft. Last year his suggestion that high-speed criticals were important had been almost ridiculed. He objected to the use of elongation and the limit of proportionality in specifying steels. The fatigue factor could be found nearly as quickly. He held that extreme accuracy in gears was essential. Messrs. Workman, Clarke and Co. calculated the allowable errors, and he maintained that trouble from these could not be eliminated by damping. In the nodal drive stiffness was aimed at in the gear case, with elastic connections to the turbine. This was the simplest arrangement from the mathematical standpoint, and, he claimed, the best system in actual working. It was in entire opposition to the author's proposal to introduce flexibility within the gear casing, which his analysis showed would introduce a new critical state. Further experience with the nodal drive had not led to a single change. He believed that flaking, pitting, fatigue fractures and blade stripping all originated in a single cause, and that the nodal drive was an effective remedy for all.

Mr. J. Wilkie said that the paper gave very little practical information, and the matters dealt with were for the metallurgist. It was, he asserted, too much to ask the engineer to abandon oil quenching on the basis of the experiments described. Dr. Hatfield had shown that repeated hammering in one direction only, might smash good material, and this was what the speaker had claimed in his paper last year. The proper remedy was the nodal drive. He believed the proposed introduction of a spring wheel to be a move in the wrong direction, but he was glad to see that the authors advocated flexibility between the turbine and the gear.

Mr. T. M. Service said he had hoped for fresh light from the authors, but was disappointed. It was well known that nickel steel could be cracked, but steel makers took steps to prevent this. He could not admit that the author's methods of heat treatment resembled those of steel makers, who, after quenching in oil from a high temperature, reheated the steel at once for tempering, instead of leaving it for days, as the authors had done. The photographs shown suggested that the cracks followed ghosts. With proper heat treatment the results were not nearly so bad as the authors' experiments would indicate. He had examined sections through 7 in. and 9 in. bars after heat treatment, and the Brinell hardness numbers only ranged from 269 to 210. He would suggest that heating and subsequent cooling in air was a dangerous practice likely to lead to internal cracks.

Mr. McLeod, speaking as a gear manufacturer, considered the paper a model one, being a record of actual experiences. His own experience with every type of gear, and not merely with marine, was that hardened gears did not last longer than those of softer material, and, in fact, unhardened gears gave the best service. There was always some risk with hardening that cracks might be produced. He had recently had some instructive experiences in this connection. In view of the change in the U.S. tariffs, raising the duties on formed cutters from 10 per cent. to 60 per cent., his firm had been frantically urged to complete delivery of a large order, and had accordingly sent large numbers to the Sheffield steel makers for hardening. In his own works this operation was conducted by a blacksmith, who had indeed a pyrometer and other appliances, but seldom used them, but, nevertheless, effected the hardening with not more than 4 per cent. to 5 per cent. of cracked cutters. The Sheffield experts had very many more failures, in spite of all their appliances. Of the cutters returned, some were cracked from keyway to tooth, and in one case the whole centre came clear away. From this experience it was evident that hardening, even by Sheffield steel makers, was attended with uncertainty. His experience was that homogeneity was much more important in pinion steel than physical characters produced by hardening. As regarded the question of accuracy, his own firm were proceeding much on the same lines as Messrs. Parsons in endeavouring to raise present standards still higher.

Mr. R. J. Walker said that some speakers had claimed that the question raised was one for the metallurgist, and to a certain extent he agreed, but it was also a matter for the engineer. Moreover, Mr. Duncan, one of the authors of the paper, was an experienced metallurgist. In all such questions it was impossible to ignore actual experience. He assured steel makers that he was not opposed to nickel steel as such. For certain specific applications it might be very suitable, but from the large amount of data now available it was clear that for pinion teeth a softer steel was needed. He had been much impressed by Admiral Goodwin's point, that the wheel had to carry the same load as the pinion, and this being so, why did not rims fracture, since pinions did. It was, he believed, imperative to adopt a softer steel; it might be a nickel steel, but must not be oil quenched. Dr. Hatfield's criticisms of the author's experiments made one thing clear, viz., that heat treatment was liable to cause cracking, and this being so why not abolish it.

Sir Charles Parsons said that the primary object of the paper was to remove the cloud which had fallen on gearing, especially since the armistice. There must be some root cause to account for the large increase in the percentage of gear failures during the past two or three years. Previously the number had been exceedingly small. Why was this the case, and why had the number increased so enormously since? In his early experiments on a model gear he had been led to the conclusion that the de Laval gear was a most beautiful mechanism, very much more foolproof than ordinary gearing. He had tested his own model gear to destruction. He used it to couple together a turbine and a dynamo, and was thus able to measure the efficiency. He obtained evidence that when the load was increased to three times the factor given by Mr. Cook there was a very rapid rolling out of the surface, although the stress on the root was only one-twentieth of the ultimate. In short, under loads producing a stress at the root ranging from one-twelfth to one twenty-seventh of the breaking stress, the surface of the tooth began to exfoliate and burr out. This was of great importance, since it showed that with suitable material a local concentration of load such as would cause a dangerous stress at the root, would be very rapidly relieved. Errors in workmanship were thus obliterated, and this was one point in which helical gears were superior to spur gears. With this experience and with that gained on the Vespasian they were making a cautious advance, but owing to circumstances this safe policy could not be adhered to, for which all of them were to blame. As a consequence the "star" steels of the makers was put into service. Such steels, no doubt, were useful, even essential in some services, but were not suitable for pinions. One point on which insufficient stress had been laid was the difference in the hardening of small and large masses of steel. When large masses were quenched in oil, the centre remained hot whilst the outside was cold. but with small objects the whole could be cooled down nearly simultaneously. Oil tempering was first introduced for guns, and was necessary if the rifling were to stand up. In guns, however, risks were accepted which were inadmissible in other services. Motor car gears no doubt were hardened and were subjected to much higher stresses than were admitted in marine gears, but motor gears were small masses. Moreover, a gear fracture was much less serious than at sea. They had all gone wrong in using hard steels for marine gears. He did not know of a single case of failure arising from sheer wear and tear. Even if softer teeth led to more wear, it would not matter much, since the cost of a pinion was small, and even if it were renewed every time the ship came under survey it would not be very serious. There were geared turbines aggregating 10,000,000 h.p. in the Navy, where reliability was very important.

Mr. Cook said he could not accept Dr. Smith's claim that torsional oscillations were the cause of the increased number of failures last year. Torsional oscillations were as likely to occur in the Navy as in the Mercantile Marine, and it was inconceivable that, with all this mass of successful practice torsional oscillations could be an important factor in failures elsewhere. One or two speakers had advocated hard steels. He could only say that, as the paper had developed, the author's opinion in favour of softer steels had been more and more confirmed. There was a practical limit to the accuracy attained in cutting, and this limit was too large to make it wise to use hard steel pinions, and it was necessary to return to the type of steel adopted consequent on the Vespasian experiments. The gears had to get bedded down, and this meant that the teeth must be capable of deformation, and this implied the use of a steel showing a large elongation and reduction of area in tensile tests. Soft steel gears would bed themselves quickly, and errors of moderate amount would not lead to fractures.

Mr. Duncan also replied. He said that whilst some of the cracks in their specimens did pass through ghosts, others did not. Some steelmakers were advocating the use for pinions of a 50-ton to 55-ton steel, but the speaker was very glad to hear Mr. McLeod say that such steels would not wear less. This, in fact, had been proved over and over again. As regard the heat treatment described in the paper he might mention that he had been for fourteen years in a steel works and could not agree that it was the general practice to reheat steel immediately after quenching. No doubt this should be the routine, but commonly the quenched steel was left lying about for long periods before being reheated and tempered. In the experiments described in the paper they had produced three cracks by heating steel 17 times. Mr. McLeod had shown that the Sheffield experts produced many more cracks with a less drastic treatment. As regards the "normalising" treatment, which Mr. Service had said was liable to produce internal cracks, this was standard practice in the case of large turbine and rotor shafts, with which there was very seldom any trouble. He did not agree with Captain Onyon's contention that the Izod test was a reliable index of the suitability of steel for use in pinions.

ELECTRIC SHIP PROPULSION.

On Thursday afternoon, the first paper read was one on "Electric Ship Propulsion," by Mr. W. Le Roy Emmet. In the absence of the author, the paper was read by Mr. Bevis P. Coulson. The paper is reprinted on page 414.

Engineer Vice-Admiral Dixon, in opening the discussion, referred to the large part played by the author in the development of electric transmission in the United States. The British Admiralty first considered the question in 1906 and afterwards at each stage in its later progress, but it is not yet satisfied that the system is possessed of advantages which warrant its introduction into any class of warship. In early days many claims were made of advantages which the system was supposed to possess, but the omission of some of these from the paper, suggested that the anticipations had not been realised. The installation of many devices might produce economy in the running of warships which might not be available under war conditions. A warship was a fighting vessel and nothing must be

introduced into its equipment which lowered its value for its war service. Whatever plant was to be fitted in such a craft must only be decided on after a complete survey of the whole equipment in relationship to the provision of an efficient and complete fighting unit. To compensate for the heavier weight of machinery when the electric drive was used, the transmission efficiency must be much higher than that obtainable with geared turbines. It was stated that for a 32-knot fast cruiser using 120,000 h.p. the plant for electric driving would be 10 lb. per horse-power more than the geared-turbine equipment. That figure might actually be nearer 15 lb. It meant that the system must be much more efficient than geared turbines to compensate for the increased weight. It must always be remembered that the fuel consumption depended on other items than the turbines. The efficiency of the boilers must be considered. Gearing could be made to give not only as high an efficiency as electrical driving but even greater. When allowances were made for all the losses in each of the two systems of working the advantage would be found to be on the side of gearing. The complete particulars and performances with installation of 60,000 h.p. and 80,000 h.p. would be informative and might have been given by the author. The question of economy in operation was not the important one in warships. Reliability during the actual use in war was the essential requirement. Geared-turbine installations were simple to operate and gave good economy, which was reasonably maintained at low loads. The fuel endurance figures given in the paper were not substantiated by the experience with British warships. Increasing the weight of the machinery and the space it took up, was not to be thought of when it meant giving up some fighting feature. The electric drive seemed to require not less than 20 per cent. more space than a similar installation of gearing. To resist the shocks of war it was essential that all the machinery be reliable in action and robust in construction. It appeared, at present, that the disadvantages of the electric drive far outweigh its advantages.

Sir Thomas Bell continued the discussion by referring to the extent of the growth of the use of geared turbines. The statement made by the author in regard to low and high-speed turbines associated with gearing, in regard to weight, complication and efficiency was quite at variance with all experience. Low-speed geared-turbine installations were no heavier and certainly not more complicated than the high-speed equipment. As regards efficiency of working, the difference in resistance of the single and double-reduction gearing was compensated for by the additional resistance of the astern unit, and there was nothing to choose between them. The figures given for electric driving could be equalled with Parsons' gearing. The design showing superimposed turbines seemed to be very cramped. Raising the centre of gravity of the power machinery in that way might create serious disadvantages, especially when very high powers are necessary.

Sir Eustace d'Eyncourt spoke next, and said that although the question was of a purely engineering character, it was of importance to a naval architect as it involved questions relating to weight and space. The electric drive was not possible for small ships, and for the large light cruisers and capital ships every ton was of the utmost consequence. With limitations in tonnage imposed in the work of the designer nothing which increased the weight of propelling machinery could be considered. The increased weight meant that the desired offensive and defensive properties of the naval vessels must be reduced. An increased weight of 535 tons for the propelling machinery in a high-speed cruiser put the scheme of electric driving out of consideration. In the limitations imposed by the Washington agreement, fuel was excluded, and any saving in economy at any speed was beside the mark. The question at issue was the consideration of deadweight in relationship to the fighting qualities of the ship. Electric driving could only be admitted if it showed a great saving in space to compensate for other disadvantages. Instead of that it involved encroachment on the magazine space. Definite figures might have been given relating to electric driving. With a loss of the order of 2 per cent. with gearing there was little scope for better results with electric transmission.

Mr. W. McLelland referred to conversations he had had with American naval officers, and said they were all enthusiastic about electric transmission. Earlier in the day, in the course of the discussion on gearing, explanations were sought for the difference in naval and mercantile experience with failures in gearing. The reason might be that naval ships were only run at full power for a very small part of their lives. There seemed no doubt that the electric transmission system meant an increase of weight and space. The installation of either system must be considered on the merits of every individual case. Mr. Emmet was to be congratulated on the facilities he had at his disposal for investigation and research in the laboratories of his firm. It would be interesting to hear what British engineers could do in comparison with the schemes presented in the paper.

Mr. S. V. Goodall thought it was a mistake to suggest that gain in economy could be set off against increased weight. If comparisons were made with old ships it would be found that they could not have been designed for their service unless they were made of increased length. If the Nelson and Rodney had to be fitted with electric propulsion the tonnage would need to be increased from 35,000 to 36,000. With the restrictions imposed by the Washington agreement, there was no doubt that the scheme of electric driving must be completely ruled out of court. The danger of splinters passing through the ventilation trunks and hitting the bus-bars must always be regarded as a serious possibility with the electric scheme.

Mr. Coulson in reply to the discussion, said that the reliability of the electric transmission plant was undoubted. Maintenance costs were a criterion of the reliability, and during the last ten years the charges for maintenance had been almost negligible. Space requirements could only be dealt with in relationship to the details of each individual installation. A great amount of information was already available in the published results with the New Mexico, in comparison with the sister ships Idaho and Mississippi. There was only one method of testing the efficiency of a war vessel and its equipment, and that method it was hoped would not be necessary. The question of the weight in a specific case could be gauged by reference to an Atlantic liner similar to the Empress of Canada. For such a steamer the whole electrical equipment would weigh about 37 lb. per shaft horse-power, which was the same as the weight of the gear equipment alone, apart from the weight of the eight turbines. It was wrong to suggest that the weight for electric driving would be nearer 15 than 10 lb. per horse-power heavier than the similar fast light cruiser. The statement in the paper was borne out by actual experience, and the example referred to was really an extreme case. In actual tests the losses amounted to 5 per cent. for double gearing and 2½ per cent. for single gearing. The electrical-driven ships had experienced much less trouble than the similar ones with gearing. The scheme of superimposed plant in the Kamoi worked out very well. The weight excess, given as 535 tons for a 32-knot fast cruiser, must be considered in relationship to many savings that might be effected in piping, shafting, and also, possibly, in armour. Several ships had been fitted with electric drive replacing geared turbines, and other cases had been studied, but in no example was extra space required. With the latest practice, the danger of possible troubles due to splinters reaching the bus-bars through wide ventilator trunks did not arise, as they were eliminated.

The president expressed the appreciation of the Institute to the author of the paper, and to Mr. Coulson, who read it, and moved that a vote of thanks be accorded to them.

Model Screw Propeller Experiments.

After the discussion on Mr. Emmett's paper had been concluded, the Duke of Northumberland had to leave the meeting, and the chair was taken by Sir Archibald Denny, who at once called upon Mr. W. C. S. Wigley to read the paper dealing with model screw experiments with mercantile ship forms, of which he was the joint author with Mr. G. S. Baker.

This paper we intend to reprint in full in a later issue, but we may here remark that it gives an account of the experimental research carried out so far in connection with screw propellers in the Froude Tank at the National Physical Laboratory. It was at first intended to limit the research to the study of wake and hull efficiency, but apparatus for measuring the torque in the propeller shaft was afterwards constructed and used, torque measurements being given in some part of the work. Results are given of experiments on the effect of immersion on the thrust and efficiency of a number of screws, and the effect of the fore and aft position of the screw on wake and thrust deduction fractions is also dealt with. Some of the varying immersion tests were made with the propeller advancing through waves and also being overtaken by waves, the results of these experiments being included in the paper. The question of the application of model results to the full-size ship is also dealt with.

The first speaker in the discussion on this paper was Mr. R. Williamson, who said he was interested in the question of hang-back, because since about 1900 he had been endeavouring to improve the efficiency of coasting steamers. He had found the propulsive efficiency to be greatly reduced in rough weather, and had concluded that the propeller surface was too small and that the blades were too close to the plating. In the coasting trade fuel economy was of secondary importance to propulsive efficiency, delays being particularly serious, and it had therefore been decided to make small alterations to the propellers in a series of similar vessels and note the results on the trial trips. His firm had built three vessels of each model and had increased the hang-back in successive vessels with corresponding increases in the surface. The results had shown an increase in propulsive efficiency, but they had not escaped accident in pursuing this policy since, in one case, all the blades had been stripped off a propeller from some unknown cause. No trouble, however, had been experienced subsequently, and during the last twenty-three years they had increased the propeller diameter by 9 per cent., the pitch by 7½ per cent., the surface by 24 per cent., and the hang-back by 75 per cent. During the same period, the speaker added, the piston speeds of the engines had been reduced by 27 per cent.; these figures, he afterwards explained, referred to a vessel of 1,000 tons. He was glad to find that the authors' work comfirmed his experience that hang-back was useful in rough water and inquired whether the authors had any information with regard to cavitation with hang-back.

The next speaker, Professor Hillhouse, asked for an explanation of the statement in the paper to the effect that "if any plane be drawn through the axis of a well-buried propeller, the action of the screw would remain the same as it was without this plane." This, the speaker remarked, seemed to imply that there was no rotary motion of the water, and he inquired whether the authors thought that that was the case.

Mr. W. J. Luke, who followed, said he was glad to see that the Froude Tank was now equipped with apparatus for propeller work, and mentioned that he thought Professor Osborne Reynolds, many years ago, had published the results of some experiments giving the thrust of propellers at different immersions. The speaker thought the results were in general agreement with those obtained by the authors, and also quoted some experiences of his own which confirmed those of Mr. Williamson. Finally, with regard to the variation of thrust when a ship was pitching, the authors' results seemed to indicate that with a tramp steamer engaged on general service, nothing but a poor performance could be obtained, since such vessels worked mainly in rough water. At the very best, the results as regards propulsion could not be more than indifferent.

The next contribution to the discussion was made by Mr. E. R. Mumford, who, after congratulating the authors on their work, pointed out that the wave-making apparatus was a valuable addition to the equipment of the Froude Tank. In a tank engaged on the commercial work of a private company, he added, there was but little time for general research work, but it would be interesting to see how the results obtained by the authors agreed with those obtained in Messrs. Denny's tank at Dumbarton. Work had been

commenced there some thirty years ago with experiments on paddle wheels and when triple screws, direct driven by turbines, had been introduced it had been necessary to design apparatus to measure thrust and torque on three screws independently. This apparatus had done good work until the introduction of reduction gearing with twin screws had permitted the thrust and torque of both screws to be measured together, since they were symmetrically arranged. The experience gained with this apparatus had enabled a third arrangement to be devised which was less complicated than that of Froude. The author's remarks in the paper as to the necessity for having the model propellers of normal design, except as regards the boss, were in agreement with the experience obtained in the Denny tank. The speaker was also in agreement with the authors' results with respect to the variation in thrust with depth of immersion and with fore and aft position. In this connection, he referred to the case of some barges which had failed to obtain the very low speed of 4 knots required of them. Model experiments, he said, had shown that in this case the ratio of effective horse-power to indicated horse-power was less than 15 per cent., owing to the fact that the screws were placed close up to the flat surface of a square-cut stern and were therefore starved of water. He had also heard of a case of a ship which was so full in the stern that it travelled astern for either direction of rotation of the screw. He gathered that it was the practice at the Froude Tank not to fit appendages, whereas at Dumbarton they considered it necessary to fit the shaft brackets. He also understood that the authors did not make allowance for the relative surface friction of model and ship, and although he realised that Froude's surface friction curves were subject to doubt, he thought it better to take this into consideration.

The only other speaker, Mr. E. V. Telfer, asked for further information on several points, remarking that experimenters differed slightly in their methods of presenting results which caused some difficulty in applying them in practice. He asked, what was the variation in thrust during the course of one revolution in the partly immersed condition. From the efficiency curve at 28 per cent. slip given in the paper, he said it might be assumed that efficiency was independent of immersion, and added that it would be very valuable if that were the case. Continuing his remarks, the speaker pointed out that the general trend of the results obtained from the Berlin and Hamburg tanks did not agree with a statement in the paper to the effect that the change of wake fraction was only 3 per cent. for a 30 per cent. increase in resistance. Referring to the formula for thrust given in the paper, viz., $T = a N^2 - b N$, the speaker mentioned that Froude had disregarded the fact that b varied as the speed of translation. More recently it had been shown that, on any of the inflow or momentum theories, thrust could be expressed in the form $T = a N^2 - b N V - c V^2$, the first portion of which agreed with Froude, but the formula contained an extra term. He added that it could be shown that the formula for effective pitch was merely a/b, and the speaker regarded this as the best hydrodynamic definition of pitch. With respect to the authors reference to the tank practice of ignoring skin friction and to the advisability of being pessimistic in the design stage, the speaker thought that pessimism should not be allowed to interfere with scientific accuracy. Scale effect, he said, was used in the Denny tank as well as in Continental and American tanks. To neglect it meant throwing aside Froude's work in splitting up resistance into its components.

No other member wishing to take part in the discussion, the chairman called upon Mr. G. S. Baker to reply. This he did rather briefly owing to the lateness of the hour. After thanking the meeting for the reception accorded the paper, Mr. Baker remarked that while his results agreed broadly with those obtained by Mr. Williamson, and also with those referred to by Mr. Luke, they had been obtained much more rapidly, the experiments on full-size ships having occupied some twenty years. In answer to Professor Hillhouse, the author remarked that the statement read did imply that there was no rotary motion of the water. He had investigated this point and had found no material distortion in a stream of coloured water passing through the propeller. He would endeavour to add the data as to cavitation with screws of large wake to the paper as printed. In answer to Mr. Luke, the speaker remarked that it was quite true that Osborne Reynolds had carried out some experiments of the character indicated, but they were comparatively few and were incomplete; Rennie, he added, had also carried out some work of this kind on the Thames. He was glad that Mr. Mumford had been able to confirm so many of the conclusions they had come to, and he would be pleased to compare results obtained at any time. Mr. Maurice Denny, the speaker continued, had recently read a paper giving the results obtained with a vane-wheel propeller, and these appeared to supplement the results given in his (the speaker's) paper. The drop in speed was due to a reduction in thrust and not in efficiency. It was quite possible to design a special propeller for partial immersion which would give a good efficiency. The matter of fitting appendages was a lengthy problem; they were sometimes fitted and sometimes not. In some cases appendages set up disturbances in the water which were not genuine, and it was desirable to avoid these as far as possible. With regard to the matter of skin friction referred to by Mr. Mumford and Mr. Telfer, the speaker remarked that he thought the paper had been a little misunderstood in this respect. It was not, he explained, the resistance of the ship that was neglected, but the fact that the difference between the resistance of the ship and the model made the screw work at a different position on the slip curve; this, however, made very little difference in the screw efficiency. To the remainder of Mr. Telfer's remarks, which the speaker said he had not heard perfectly, he would prefer to reply later in writing.

After a vote of thanks to the authors had been proposed by the chairman, and carried by acclamation, the meeting was adjourned.

The Powering of Motor Ships.

At the evening meeting on Thursday, the 22nd inst., the chair was taken by Sir George Goodwin, and a paper by Mr. K. C. Barnaby entitled "The Powering of Motor Ships," was read and discussed. In the absence of Mr. Barnaby abroad the paper was read by the secretary. We need not refer to its contents here, as we reprint it on page 412 of this issue.

Mr. James Richardson opened the discussion. He said that while the motor ship had developed greatly during recent years and some of the problems connected with it might be looked upon as solved, there were other problems that were to some extent still open questions. Some of these were connected with propeller speed and the matter was dealt with by Mr. Barnaby. He pleaded for a reduction in propeller speeds and such a plea might be generally well founded, but when the problem of the motor-ship came to be looked at as a whole it would generally be found that combined efficiency would not be improved by cutting down propeller speeds owing to the increased weights which would be involved. In saying this he was assuming a constant piston speed for the Diesel engine. In the practical operation of a ship the sea was more often rough than smooth, and the smaller propeller associated with a higher number of revolutions had the advantage that it kept under the water better than a larger one. The main question was that of overall efficiency, and the figures he gave for the motor-ship Pinzon in his paper of last year showed that it had a speed 1 knot greater than that of a corresponding steamship, and that the consumption of oil was only one-fifth of that of coal by the steamer. These figures covered all services.

Referring to the question of the loss of power of oil engines in the Tropics, Mr. Richardson said that his experience did not show any evidence of the 5 per cent. to 10 per cent. loss mentioned in the paper. Any effect due to the lesser quantity of oxygen drawn into the cylinders was more than counterbalanced by the warmer and consequently more fluid lubricating oil and fuel. This condition seemed to lead to better combustion. He did not think the effect of less oxygen could be of any importance except perhaps in some cases in which the oxygen content was near the limit, possibly in some types of two-cycle engine. It was improbable with four-cycle engines.

On the question of reducing propeller speed by gearing, Mr. Richardson said that he would certainly not advocate gearing except in some very special cases, and he could not agree with the author's remarks about electric gearing and the oil engine being an inherently bad reverser. The modern Diesel engine was a good starter and reverser, and even the earlier troubles were with starting and not with reversing. He had been concerned with the taking of a motor ship both ways the full length of the Manchester Ship Canal and there had been no trouble of any kind and the flexibility was perfect. He agreed with Mr. Barnaby that it would be better if Diesel engines were specified in terms of brake horse-power, but so long as the shipowner continued to think of steamers in terms of indicated h.p. the motor-ship builders had to follow the same practice.

Mr. T. Donaldson said that the paper would be very useful to ordinary engineers and would perhaps save some of them from disappointment. It was well-balanced, and while treating of generalities did not forget particulars.

Mr. G. S. Baker said that the paper might be looked upon as the first chapter in a broad survey which should cover the oil engine, geared turbine and the electric drive. The whole question was one of overall efficiency, and there was no value in a very efficient oil engine if the ship in which it was fitted was not going to be profitable. A few years ago Mr. Anderson had read a paper before the Institution on the overall working efficiency of a cargo steamer. Mr. Barnaby's paper really dealt with a branch of this same subject. There was an important point in connection with the placing of the propeller which bore on this matter. Mr. Barnaby had followed published data, and had naturally assumed that in each case the propeller was placed in the best position. It had been found, however, in connection with models submitted for test in the tank of the National Physical Laboratory that the screw was frequently wrongly placed. With motor ships the screw being smaller there was more room available to place it in various positions. Frequently it was placed low to keep it well immersed, but this made it very inefficient in shallow water.

Another matter which had to be considered in connection with motor ships was that the turning moment varied more than was the case in steamers, so that there was more likelihood of the screw breaking down in thrust. To meet this condition it was necessary to fine down the stern, or place the screw where eddy water would not affect it. It was stated in the paper that "it is often advocated that propellers for Diesels should be designed to absorb the full power at just under the normal revolutions per minute." The author, however, did not state at what speed this condition was to be assumed. If absolutely full power and full revolutions were taken for fine weather conditions then in bad weather the engine would be overloaded. Some speed lower than the full speed should be designed for. He thought reduction gear with high-speed Diesel engines would give trouble owing to the variation in torque and the breakdown of the propeller thrust. The fluctuations of tooth pressure would probably also cause difficulties.

Sir John I. Thornycroft thought that there was no question of the falling-off of efficiency of oil engines in the tropics. The normal man also fell off in efficiency, and it was quite likely that some of the falling-off of efficiency of plant was due to this diminution of efficiency of the attending personnel.

Mr. Perrin thought that the point about B.H.P. raised in the paper was a good one. B.H.P. could be connected with effective horse-power, which could be measured in tank experiments. Mr. Barnaby's model experiment was very ingenious, but the low cost of tank experiments now brought them within the reach of everyone.

Mr. J. Foster King said the paper was interesting to an "old hand" as showing that all virtue did not lie with the internal combustion engine. It would be useful in discussions with shipowners. A tribute of thanks to the author was also paid by Mr. John Smith. Mr. R. Williamson said that owners of tramp ships were still doubtful about

Diesel engines, and whether they could get an engine-room personnel that would handle a Diesel the way they handled a steam engine. There was also the question of tonnage. Dock dues were paid on net tonnage, and it was important to know if the present low net tonnage could be got with Diesel engines. There was no doubt about the saving of fuel with oil engines, but a further question which should be considered was that of depreciation, and the value of a Diesel engine when 10 to 15 years old.

Mr. Sydney Barnaby, who was asked to reply to the discussion by Sir George Goodwin said that he could not deal with it in detail. The paper had been sent to him by his son but a little time before the meeting, and he had not been concerned with its preparation in any way. The paper might be looked upon as of a preliminary nature only. It certainly did not set out to advocate any particular type of Diesel engine, but rather to give a rough-and-ready method of finding the most suitable engine on the market for any specified conditions.

Sir George Goodwin in closing the proceedings, described the paper as a remarkable production in view of the fact that it had been written in the Tropics, and with few facilities available. On the question of the reversing and manipulation of Diesel engines, he would remind the meeting that a committee of the Institution, in conjunction with the Institution of Mechanical Engineers, had been appointed some little time ago to investigate these and similar problems. Bench trials were likely to start next month. The meeting then adjourned until the following morning.

(To be continued.)

THE MANUFACTURE OF THE BARLOCK TYPEWRITER.

THE history of the typewriter, like that of so many other devices, begins with an invention that was born out of due time. As long ago as 1714 an Englishman named Henry Mill took out a British patent for "An Artificial Machine or Method for the Impressing and Transcribing Letters, singly or progressively one after another as in writing, whereby all writing whatever may be engrossed in paper or parchment so neat and exact as not to be distinguished from print." This is clearly the germ of the modern typewriter, but how the inventor carried out his idea is not known. Nor does it greatly matter, for no invention is of any practical use until the state of the mechanical arts is such that it can be produced commercially, and until there is a sufficient demand to justify its manufacture. Neither of these conditions existed in Henry Mills' time, and consequently his idea lay dormant for more than a hundred years. In 1829 interest was again shown in the subject, and an American, William A. Burt, obtained a patent for a "typographer." The first really practical machine appeared in 1866, the invention of James Pratt, an American living in London, and from that time onwards the design has been steadily improved by different inventors.

The Barlock typewriter was the outcome of the association of Mr. W. J. Richardson, an Englishman, with an American inventor in the early eighties. Those were the very early days of commercial typewriters, and Mr. Richardson stipulated for a machine in which high speed and quality of work should take precedence over considerations of price. The Barlock Typewriter Company was formed and in 1888 it produced its first model. This was the earliest machine to have "visible writing," and it was equally the first to have a duplicate keyboard, automatic ink-ribbon reversing gear, removable ribbon spools, adjustable margin stops, automatic line spacing, adjustable type-bar bearings and a lock to the type-bars. It was this last feature from which the machine derived its name. In order to secure exact alignment of the type upon which the satisfactory appearance of the writing depends so largely, each of the type-bars was controlled at the printing point by falling between a pair of conical pins, which centered it exactly in the required place. This was a most important improvement, and, together with the feature of visible writing and other characteristics, it placed the Barlock machine well in the forefront among typewriters. Further inventions and improvements in detail resulted in the production of successive models, all showing advances towards the versatility of scope and the mechanical perfection which characterise the typewriter of to-day.

It is noteworthy that the Barlock Typewriter Company has always been an entirely British undertaking. The capital, management, salesmen, clerks and mechanics all being British. The machines, however, were manufactured in America, the whole output of the factory being shipped to London. In 1898, when the company had been established for ten years and its products had won for themselves an assured position negotiations were entered into with a view to buying the American interests in the patents and transferring the manufacture of the typewriters to England, but capital could not be raised for the purpose. In 1908 a further attempt along the same lines met with failure, so the company decided to introduce the manufacture gradually to this country. In accordance with this policy a beginning was made by arranging for a small proportion of their typewriters to be imported as parts, to be assembled over here. This proportion was steadily increased, until eventually no complete machines were imported, and all the company's typewriters were built in London. It was soon found possible to manufacture certain parts in London in substitution of imported parts, and so the machines became more and more British productions. Finally, in 1913, all the remaining American interests in the patents were purchased and plans were made for manufacturing throughout in England. The outbreak of war, however, put a temporary stop to anything of this kind, and the scheme had to be held in abeyance until more or less normal conditions again prevailed. It is deserving of honourable mention that over 200 of the company's employees enlisted as volunteers in the Great War.

After the Armistice the Barlock Company at once took steps to start manufacturing, but with fresh plans and on a larger scale than originally contemplated. It was decided to erect a new works of modern type, designed especially for the production of the multitudinous and delicate parts which go to the making of a typewriter, under the most favourable conditions. The choice of locality fell upon Nottingham, where a clear dry atmosphere with plenty of light could generally be counted upon and which was situated favourably for distribution both to inland centres and the shipping ports of London, Liverpool and Hull. The company acquired eleven acres of land on the outskirts of the city and proceeded with the erection of the first section of a factory, which, when completed, would provide for the employment of 3,000 workpeople. The first section, which has now been in operation for about two years, is a single-storey building with north-lighted saw-tooth roof covering, 30,000 sq. ft of floor area and having accommodation for 500 workpeople. The Barlock Company stipulated that the whole of the steelwork, building material and electric power and lighting apparatus should be of British manufacture, and the same policy was adhered to with regard to the machinery and equipment.

The first work undertaken at the new factory was the manufacture of typewriter ribbons, this having long been a speciality of the Company in their previous premises. The Barlock Company make ribbons for every kind of typewriter in use, and have obtained a high reputation for the quality of their products. The ribbons are not woven to the finished width, but are made from rolls of calico tightly wound on thick cardboard tubes. These rolls are sliced into discs by rotary knives, the knives cutting right through the cardboard tube. The discs are of the exact width that the ribbon is to be, and are varnished on each side to prevent fraying and to form the equivalent of selvedges. They are mounted on the mandrel of the inking machine, and as the ribbon is unwound from them it passes between rollers, one of which is kept inked by running in contact with a roller which runs in contact with ink in a reservoir. Double coloured ribbons have each half of their width inked in turn by this method. After having been inked the ribbons are wound on the spools suitable for the particular kind of typewriter for which the ribbon is made, and are despatched ready for the use of the typist.

The ribbon and carbon paper department is, of course, quite a small portion of the whole factory, the bulk of which is given over to the various operations involved in the complete manufacture of the Barlock typewriter. This machine, in its present form known as "Model 16 single shift key," is of handsome and substantial appearance, the mechanism being completely protected by the enamelled casting which forms the back and sides of the machine. The nature of the mechanism and the action of the parts will be understood from Fig. 1, annexed. In the illustration the various rows

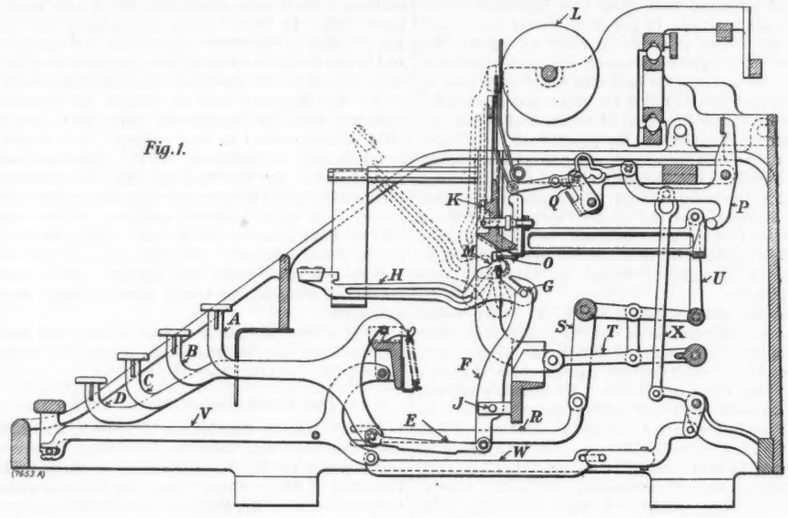
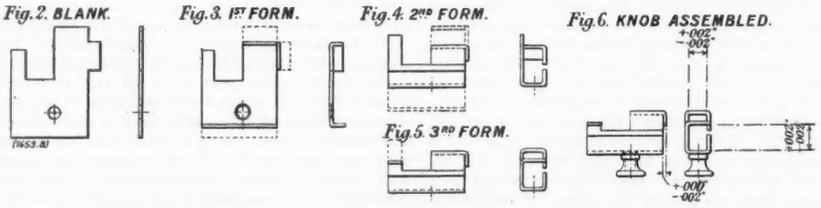


Fig. 1.



of key-levers are shown at A, B, C and D. These levers are all pivoted to the top of a cast-iron transverse bar which is attached to the framing of the machine, and each is returned to the normal position after being struck by the small helical tension spring indicated on the drawing. The depression of each key forces the corresponding sub-lever link E to the right, and causes the sub-lever F to rotate about its fulcrum J. A pin G at the upper end of each sub-lever rests in the bottom of a slot in the type-bar H which it actuates. These type-bars are pivoted at M near the open ends of their slots. It is obvious that as the pin G moves to the left under the action of the key-lever it travels up the slot and diminishes the virtual arm of the lever G M. Thus a rapidly accelerating movement is given to the type-bar, causing a smart blow to be struck by the type.

The various lengths of the key-levers which are employed in order to provide a convenient keyboard, would of course result in a difference in the motion of the respective type-bars were there no arrangement for compensating such an effect. Compensation is provided by an alteration in the position of the pivots J of the sub-levers, so that the ratio of the arms of the sub-levers is altered sufficiently to neutralise exactly the effect of the varying lengths of the key-levers. The type-bars, rotating about pivots M are brought to rest by the anvil face K, at exactly the same moment as the type strikes the platen L. This feature ensures that varying strengths of touch do not sensibly affect the evenness of the typing. Near the point M it will be seen that the type-bars are provided with a rounded shoulder. During the upward movement of each type-bar this shoulder strikes the bail O; this causes the dog-rocker P to operate the carriage escapement and the ribbon gear Q. The bail is a semicircular frame, curved to fit the segment which carries the type-bars so that it is struck equally by all the type-bars.

To enable the capital letters to be typed, the segment and frame carrying the type-bars and sub-levers are moved bodily upwards by depressing a shift lever, which in the illustration lies exactly behind the key-lever D. When this shift lever is pressed down, the link R swings the bell-crank lever S. This has the effect of simultaneously lifting the bail O by means of the link U and the type-bar segment by means of the lever T. If desired, the mechanism may be locked in the upper or "capital" position. Spacing is accomplished by means of the space key lever V which operates through links W and X. Pressure on the spacing bar thus depresses the rocker P and so operates the carriage escapement.

An inspection of Fig. 1 gives some idea of the multiplicity of parts which go to the making of a modern typewriter, especially when it is remembered that each one of the keys requires its own line of mechanism. Moreover, the ribbon winding gear and the carriage mechanism involve a good deal of complex work which is not even indicated on the drawing we publish, since the function of the latter is merely to show the main mechanical features of the keyboard action. As a typical example of manufacturing methods we will describe the processes employed in one single item, namely, the margin stop which limits the motion of the carriage. This, although such a simple little article, and one which would almost escape notice when the whole machine is inspected, involves no fewer than seventeen distinct operations for its production, not counting the inspections which take place after every operation. The material used is sheet steel, in the form of strip. The first operation consists of blanking and piercing, producing pieces in the form of Fig. 2. Operation 2 consists in countersinking the hole; then follow three forming operations, with the results shown in Figs. 3, 4 and 5. The sixth operation is to planish the article; the seventh, eighth and ninth consist in drilling, "burring" and tapping the hole for the knob; the tenth operation is the hardening and tempering of the piece, and at the eleventh it is tumbled and buffed to give the required finish. The next operation is to turn the knob, which is done on an automatic machine. The thirteenth operation is to assemble and rivet the knob in position; then to stamp the arrow; next to buff the edges and top of knob; next to nickel-plate the complete article; while the seventeenth and final operation is to polish the edges and the top of the knob. The finished article is shown in Fig. 6, together with the permissible limits of error.

The Barlock Company manufacture one standard typewriter only, this having four replaceable carriages to accommodate work of different widths. The smallest carriage takes paper 11 in. wide, and the largest takes a sheet 27 in. wide. Each carriage is quite complete in itself, and can be removed, replaced or changed without the use of any tools, by any ordinary operator. The new Barlock is fitted with 90 characters instead of the usual 84, and the Company have designed a special Engineer's Keyboard, enabling all fractions up to 63/64ths to be typed without the use of the shift key. The first machine turned out of the new Barlock factory was delivered in April, 1921. Each typewriter comprises 597 different parts, all of which are made at Nottingham, and the average number of finished pieces passing per week into the finished part stores is 129,220 at the present time. These figures give some idea of the problems of manufacture and organisation which arise in the inauguration of such a factory as that of the Barlock Company, and when it is remembered that the average tolerance of typewriter parts is only about one-thousandth of an inch, the quality of the work which has to be maintained will be evident.

The illustrations on page 400 give a good idea, both of the general nature of the interior of the works and of the manufacturing activity which prevails. The works are very self contained, no parts of the typewriter being brought in from outside except the rough castings of the frame. As an examination of any typewriter will show, a large proportion of the parts consist of steel stampings of greater or less complexity. The material for these parts arrives in the form of steel strip of the requisite gauge thickness and the parts are blanked, pressed and drawn in the department of which a portion is shown in Fig. 7. Fig. 8 shows the drilling bay equipped with rows of multi-spindle drills, and Fig. 9 the automatic screw-making machines for the production of the innumerable small screws required by the firm. Fig. 10 gives a general view of the assembly bay, where the various units of the machine are put together and finally combined to form a complete typewriter. As will be noticed the operatives are practically all girls, the lightness and cleanliness of the work rendering it particularly suitable for female labour. Up to the present day-work payment is the rule, but it is the intention to introduce payment by results in due course. The operatives are supervised by male section hands. The latter are all skilled tool makers, each of whom graduates in the company's tool room before being placed in charge of a section. They are thus practically conversant with every peculiarity of the tools upon which the accuracy of the work depends, and link up in the most efficient manner the tool designers and makers with the actual work of production.

COASTAL MOTOR BOATS ("C.M.B."): THEIR DESIGN AND SERVICE DURING THE WAR.*

By Sir. J. E. THORNYCROFT, K.B.E., Member of Council, and Lieutenant BREMNER, R.N., D.S.O.

IN the early summer of 1915, three officers, Lieutenants Hampden, Bremner and Anson, suggested the possibility of utilising quite small motor boats to go over the mine-fields and attack the German bases. After the suggestion had been tentatively approved it was decided that, to give any possibility of success, the boats complete with an 18-in. torpedo should not exceed the weight of the ordinary 30-ft. motor boats carried in the davits of the light cruisers. They should have a speed of not less than 30 knots when carrying the torpedo and a full load of fuel for a considerable radius of action. At first these conditions seemed almost impossible, as the high-speed racing boats, which they would necessarily closely follow in design, did not carry any greater load than their crew of two or three men and fuel only in sufficient quantity for a short race. They had never been designed with lifting gear and stiffening to enable them to be slung in davits with a heavy load. The limit of the weight had to be under 4¼ tons, of which the torpedo alone was about ¾ ton, but from available data concerning the particular high speed motor boat which one of the authors' firm had designed and built, and from fresh model experiments which were undertaken, it was felt to be pretty certain they could be fulfilled. This design was the result of many years of experiment by Sir John I. Thornycroft, the designer of the Lightning, Torpedo Boat No. 1 of the British Navy, who from his earliest days has always been interested in the design of boats which would skim on the surface. In 1910 he built Miranda IV., which would not only skim well on the surface of the water when driven at high speed, but also had good sea-going qualities. Before the war there had been a considerable development in skimming boats of various designs, following the proposals of the Rev. C. M. Ramus to construct the bottom of the hull in the form of a series of inclined planes so as to lift the hull by the reaction of the water on to the surface, but boats of rectangular section, such as he proposed, could not be good sea boats, and in rough water they slammed very badly. The successful design referred to had a form which was rather beamy and with a single step formed by the fore body, which in itself took the form of a normal bow, but built with a sharp angle of chine running from the step to the stem. This sharp angle gives a lift not only in a fore and aft direction, but in a lateral one as well, and by keeping a distinct rise of floor at all the sections back to the step a form is produced which does not slam unduly in rough water. Boats with hulls of this form can be made to skim satisfactorily when weighing as much as 45 lb. per horse-power. After considering different dimensions it was concluded that it would be necessary to have a boat of 40 ft. in length to carry the torpedo and fulfil the other requirements (see Fig. 1, Plate XXVI, and Fig. 6, page 394).

It is not proposed to go into the history of the development of skimming boats in this paper, nor to refer at any length to the theoretical considerations regarding them. Mr. A. W. Johns, Assistant-Director of Naval Construction, wrote an article which was published in ENGINEERING in September, 1920, which will be found to give a very clear statement of the laws governing skimming effects, and it is suggested that those who want further information should refer to that article.

While the condition was laid down that the total weight of boat and load should be less than 4¼ tons, in order to use the existing davits, there was the quite independent limit of weight within which the boat must be kept in order to give the speed performance of over 30 knots. The weight of the machinery which could be obtained for the power required, estimated at 250 h.p., was known, and the difference between this and 4¼ tons was available for the hull and torpedo gear, &c. It was obvious that no ordinary form of torpedo discharge gear could be used, as no margin of weight was available, and that the arrangements for carrying the torpedo must be incorporated in the structural hull of the boat itself.

Before referring to the detailed arrangements of the torpedo gear, the design and construction of the boats will be given. It has been stated that the model followed very closely Miranda IV, which was built as a purely racing boat and which gave a speed of 35 knots, but carried very little load. To provide for the torpedo the above-water form of the stern had to be modified, and to make the boats as good as possible for rough water the fore body was made rather less flat. In quite smooth water the flatter form is better for speed, but it is not so good when the water is rough. Experience with high-speed racing boats had shown that it was not possible to make nearly so light a hull that would stand in steel as in wood, and also that the timber construction must be elastic, it having been found that any knees of sawn timbers were invariably broken or pulled away from other parts of the structure, and that good results could only be obtained by using timbers of American elm, which would easily bend, and two or more skins of light planking. It will be noted that the construction which was adopted is almost identical to that which has since been carried out, on a lighter scale, in the most successful seaplanes. With such a very light construction, the problem of attaching the sling plates and gear, to enable the boat to be carried in davits, was an interesting one. As the motor and the torpedo were a large proportion of the total weight it was decided that the best arrangement would be to take their weight as direct as possible on to the sling gear, and so it was attached primarily to the engine bearers in the bow, and to the rails of the torpedo trough in the stern. The torpedo trough was made to form a longitudinal girder in the after part, and the engine bearers a longitudinal girder in the fore part of the boat. The drawings are given showing how the detailed construction was carried out.

From previous experiments with different forms of hull the builders were satisfied that the best form had been adopted, but model experiments and trials of actual boats of alternative forms were tried. The diagram (Fig. 3, Plate XXVI) giving the relative performances of the different models shows how they compared. It was suggested that a V-bottomed flat stern boat without a step might have better sea-going qualities, as it would be less likely to slam in rough water, but the resistance curve showed that it would be impossible to get the required speed with such a form. It was thought that a hollow-bottom form might be suitable, and would have the advantage of showing less spray, but here again the resistance curve showed that the speed could not be so great, and with the peculiar form it was almost impossible to place the motors anywhere but in the after part of the boat, and this would make it very difficult to carry the torpedoes. This form of hull was also necessarily heavier for given dimensions. A 40-ft. boat of this design was, however, built, but it was never actually used in service. The hollow-bottom form of boat, as built in America and known as the Hickman Sea Sled, is fitted with semi-immersed propellers. These were also tried on what may be called the standard 40-ft. C.M.B.'s as well, and the hollow-bottom experimental boat was tried with exactly

* Abstract of a paper read before the Institution of Naval Architects, March 21, 1923.

the same propellers and gear as the standard boats, so that every alternative arrangement was given a trial. The average speed of the first 40-footers, which was considerably improved upon in the later boats, was 33·5 knots with 250 h.p., the screws having a pitch of 36 in., and a diameter of 22·5 in., the displacement with full load of fuel, crew, torpedo and sea-going gear being 4·25 tons. With a skimming boat it is not easy to say exactly what the resistance is, and, therefore, to claim a very high efficiency of the propeller, but there could be no doubt that it was very good. Besides the ordinary design a special form was used on some of the boats, which is illustrated in Fig. 4 (Plate XXVI) and Fig. 9, annexed. The reason for adopting this form was the facility it gave to pass over obstructions such as wires or booms. It will be seen that it is not unlike some of the earliest screw propellers ever tried, and it is very remarkable that the efficiency was almost as good as the best propeller of normal type that could be designed. With model experiments it is comparatively easy to show the relative merits of different forms of hull, although it is not so easy to foretell what the actual resistance of a full-size boat will be. Nevertheless the model experiments with the different forms of hull which have been referred to and the results with the actual boats and similar motors corresponded extremely well.

After the 40 ft. boats had been proved a success a large number of 55-ft. boats of about double displacement, fitted with twin engines and carrying two torpedoes, or a torpedo and depth charges, were built. The first few of these were fitted with two 250-h.p. engines, but latterly with engines of increased power. With two motors of 375 h.p. each a speed of 40 knots, with a full load, on a 2 hours' trial was obtained. Boats recently delivered to the French Government made the run from the Thames at Westminster to Cherbourg in a running time of 7 hours 56 minutes, breaking the run at Portsmouth to pick up fuel. The distance of the run being 270 miles, the speed works out at 34 knots.

The sheer draught and midship section (Figs. 13, opposite, and 14 and 14A, Plate XXVI), show the scantlings and the construction of the trough for the torpedoes, and how they were arranged to give the necessary strength to the hull. The fact of the trough cutting through the deck of all the after part of the boat made it necessary to tie the boat together in some other way. This was done by making the supports of the trough in a vertical plane act as cantilever girders to hold the deck and the top of the trough in position. It will be seen that the construction of the trough including the rails for the torpedoes was of wood, with the exception of the attachment for the ram impulse gear and the release gear, which was incorporated in the lifting attachment, and the wooden-supporting rails were faced with bronze. The attachments for lifting the boat (Fig. 2, Plate XXVI), which consisted of hooks on either side of the torpedo trough, were carried down past it to the continuation of the engine bearers which formed the internal keelson, so that the weight of the torpedo on the rails was taken directly to the hooks as mentioned when referring to the lifting gear, and the hull of the boat might be considered to be carried from the attachment to the keelson. To discharge the torpedo satisfactorily it was found that a velocity of 25 ft. per second, about 17 knots, was sufficient, and assuming the boat was travelling at 30 knots, the torpedo would enter the water with the tail slightly down at a forward velocity of 13 knots. The impulse to push the torpedo out was given by a long-stroke ram, fitted with an aluminium cap, or "bell-head" as it was named, which was long enough to cover the firing pistol and bore of the torpedo head where the spherical end was near the full diameter (Fig. 5, Plate XXVI). While at first it was doubted if the head would be stiff enough to take the thrust without buckling, it was found that by making the surface in contact about 3 in. wide, no deformation occurred. The bell-head was fitted with openings so that access was given to the firing pistol to withdraw the safety pin. It was at first thought that it would be best to operate the ram by compressed air, but it was found that the reservoirs would be too heavy, and so it was arranged to make the supply of high-pressure gas to operate it by burning cordite in an enclosed vessel at the moment the torpedo was to be fired; 1,500 gr. of No. 37 cordite were found to be sufficient, giving a pressure of about 4 tons in the explosion vessel, which was reduced, by taking the gases through a small orifice, to about 1,000 lb. pressure in the ram. The diagram shows the construction of the cartridge container and explosion vessel. To avoid all possibility of firing prematurely the pistol was not cocked before the moment of firing, the striker being operated by a pull through a wedge; the officer in charge of the boat, having the firing lever alongside the steering wheel, by the one motion withdrew the side stops which were in the form of bolts passing through supporting rails and deck against the after side lugs, and then operated the firing pistol.

It has already been explained that the supporting rails were extended beyond the stern of the boat and, to avoid the possibility of the head of the torpedo or pistol striking the end of the trough or stern of the boat, the head of the torpedo was supported in a loose stirrup until it was clear of the rails, the stirrup, as soon as the torpedo was in the water, falling clear. The running of the torpedoes fired in this way was most satisfactory, the depth keeping being found generally better than any other method of discharge. For travelling in the seaway, jambing screws were arranged to hold the torpedo tightly down on to the rails. Access was arranged through the bottom of the trough where necessary to get at the underside of the torpedo in case it had to remain in the trough for a long period, and for use in the winter arrangements were made to keep it warm by a connection from the exhaust of the engine. In the 55-ft. boats carrying two torpedoes the arrangements were the same, but in duplicate.

Propelling Machinery.—To provide the 250-h.p. which was necessary, a weight of only 2,100 lb. was available, and meant the employment of motors which were very little heavier per horse-power than those for aeroplane use, but for work at sea there are many conditions which make a motor of the pure aeroplane type unsuitable. During the rush to provide boats quickly a certain number of motors designed for aeroplanes were used, but those which have proved really successful were designed specially for those boats, the 250-h.p. twelve-cylinder V-pattern engines having cylinders of 5¼ in. by 7 in. They developed their power at 1,400 revolutions. The motors built for later boats were also V-pattern twelve-cylinder engines, having cylinders of 5¾ in. by 7 in., which developed about 375 h.p. at 1,600 revolutions, and weighed 2,600 lb. The first boats were not fitted with reversing gear, but the later twin-screw boats were so fitted on one engine, for manœuvring. The fuel capacity of the 40-ft. boats was 100 gallons, which gave a radius of 160 miles, and the 55-footers carried 350 gallons, which gave 200 miles, the difference in radius at full or reduced speed being not very great, as the resistance at a slow speed when the boats are not skimming is proportionately greater. The crews of the smaller boats consisted of two officers and one motor mechanic, and of the larger boats two officers, two motor mechanics and, in some cases, one wireless operator.

A comparison between the radius of action and speed of these boats fitted with petrol engines and that of the early steam torpedo boats is of interest. The last second-class torpedo boats which were built to be carried on the mother-ship Heckla, were 60 ft. in length, and carried one 14-in. torpedo. Their power was about 250 h.p., and they gave a speed of about 16 knots. Their fuel capacity was nominally sufficient for 3 hours' full speed, but the difficulty of firing the boilers in a choppy sea was very great, and it was recognised as impossible to make a long run and be in a condition to make an attack at the end. Assuming they did their nominal performance, the 40-ft. C.M.B. does twice the speed and carries a torpedo of more than double the power. A comparison of the weights of rather earlier second-class boats, which carried two 14-in. torpedoes in troughs, with those of the 55-ft. C.M.B.'s, is given on the opposite page.

It has been explained that when the proposal to use C.M.B.'s was first made it was intended that they should be used to attack the enemy bases in the North Sea, that they should be carried by light cruisers and lowered when the minefields prevented the cruisers going any farther. It was not possible to carry more than two boats on each cruiser, and the advisability of fitting out a special carrying vessel or mother-ship which could take six at once was considered. It was not found possible to appropriate a vessel until the latter part of the war, when the cruiser Diamond was fitted out and took six 40-footers to the Mediterannean. While they were carried by the light cruisers as originally proposed, no serious attacks were made on the German bases, and the first boats built were sent to operate on the Belgian coast with Dunkirk as an advanced base. Other bases were organised at Dover, Portsmouth, Osea Island and Portland.

The first success was obtained with the boats operating from Dunkirk early in 1917, when four of them, under the command of Lieutenant Beckett, attacked German destroyers off Ostend, sinking one and scoring several other hits. Largely as a result of this successful operation, more boats were ordered, including twin-screw 55-ft. boats, an experimental one having already been built. Captain Walwyn, of the Anti-Submarine Department, suggested the employment of these 55-ft. boats, carrying a single torpedo and four depth charges, for anti-submarine work, and a great deal of patrol work was eventually done, from all the bases, with these 55-footers. Owing to their larger dimensions they were, of course, better sea boats than the 40-footers, and in the Channel

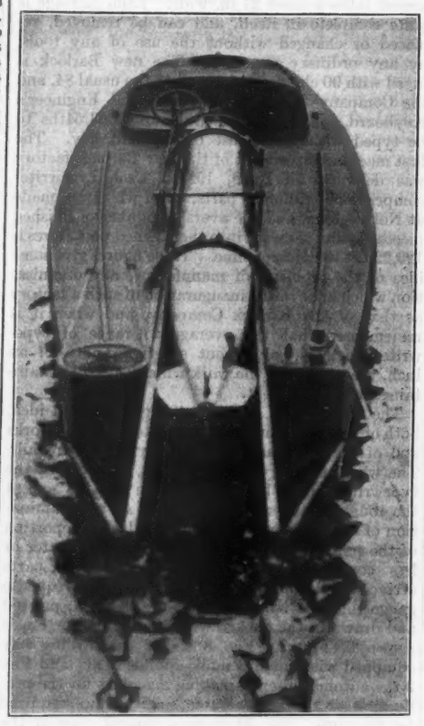


FIG. 6. STERN VIEW OF 40-FT. BOAT SHOWING HOW TORPEDO IS CARRIED.

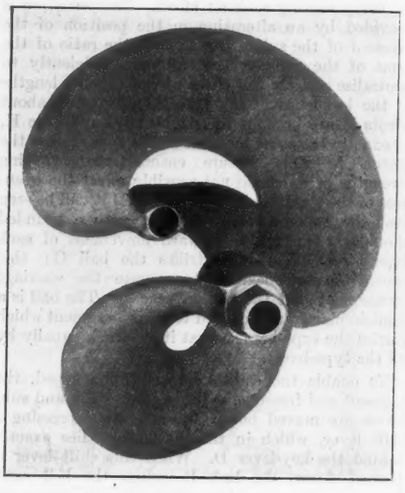


FIG. 9. THE SPIRAL PROPELLER FITTED FOR JUMPING WIRES.

FIG. 10.

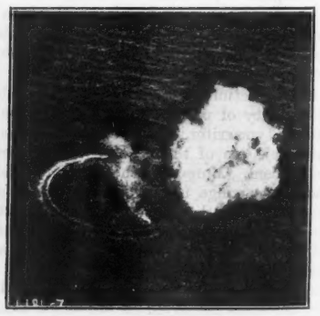


FIG. 11.

FIGS. 10 AND 11. PHOTOGRAPHS OF THE C.M.B.'S IN ACTION WITH ENEMY AIRCRAFT OFF THE GERMAN COAST. THE PHOTOGRAPHS WERE TAKEN BY A GERMAN AIRMAN.

and on the Belgian coast largely replaced them. The boats patrolled the Belgian coast inside the sands, and were able to keep a constant watch on Ostend and Zeebrugge. On one occasion, when five German destroyers attempted to dash through the Straits, C.M.B.'s met them on the return and succeeded in torpedoing one of them.

As a counter to the C.M.B.'s at Dunkirk, the Germans established a base at Blankenberghe for motor boats of somewhat similar dimensions, which they called P.M.B.'s (patrol motor boats), but they were so much slower that they never came to close quarters with the British boats, work was done by them on the Belgian Coast. The special mines which had been designed for laying from submarines were carried on trolleys supported on the rails in the torpedo troughs, and towards the end of the war a number of 70-ft. boats were built to carry four of the largest type of mines.

The blocking actions at Zeebrugge and Ostend have been fully described as far as the work of the larger vessels was concerned. Official reports made reference to the good work done by the C.M.B.'s, but it may not be out of place to refer in more detail to the part they played. In the Zeebrugge action the C.M.B.'s were not

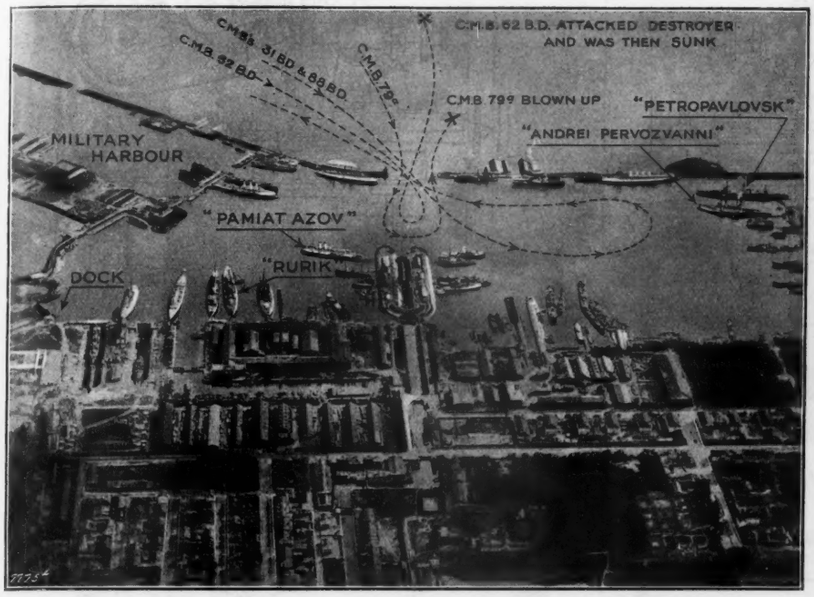
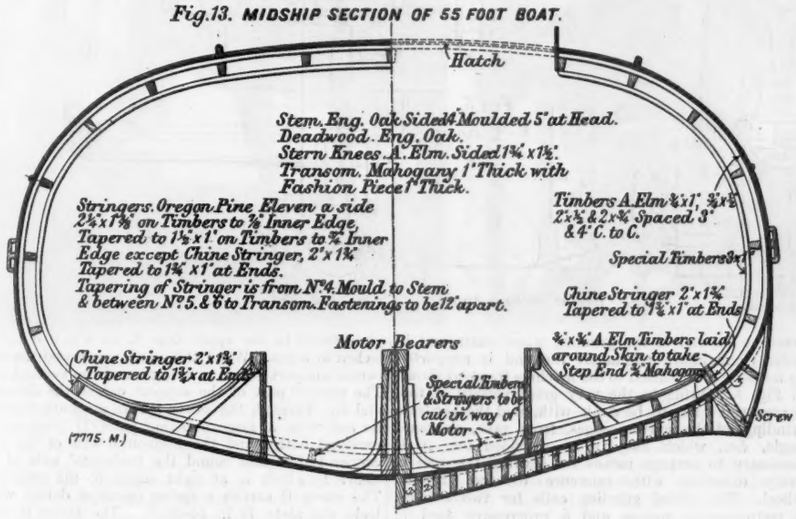


FIG. 12. THIS PHOTOGRAPH WAS TAKEN THE DAY PRECEDING THE C.M.B. ATTACK, AND SHOWS THE POSITION OF THE BOLSHEVIK VESSELS INSIDE KRONSTADT HARBOUR.

Fig. 13. MIDSHIP SECTION OF 55 FOOT BOAT.


Hatch
Stem, Eng. Oak Sided 4" Moulded 5" at Head.
Deadwood. Eng. Oak.
Stern Knees. A. Elm. Sided 1¾" x 1½".
Transom, Mahogany 1" Thick with Fashion Piece 1" Thick.
Stringers. Oregon Pine. Eleven a side 2½" x 1⅞" on Timbers to ⅞" Inner Edge. Tapered to 1½" x 1" on Timbers to ⅞" Inner Edge except Chine Stringer, 2" x 1¾" Tapered to 1¾" x 1" at Ends.
Tapering of Stringer is from N°4. Mould to Stem & between N°5. & 6 to Transom. Fastenings to be 12" apart.
Timbers A. Elm ⅞" x 1", ¾" x ½" 2" x ½" & 2" x ¾" Spaced 3" & 4" C. to C.
Special Timbers 3" x 1"
Chine Stringer 2" x 1¾" Tapered to 1½" x 1" at Ends
¾" x ¾" A. Elm Timbers laid around Skin to take Step End ¾" Mahogany
Motor Bearers
Chine Stringer 2" x 1¾" Tapered to 1¾" x 1" at Ends
Special Timbers & Stringers to be cut in way of Motor
Screw
(7775. M.)

not daring to patrol any distance from their base when the C.M.B.'s were out, and were never actually seen by our boats.

The C.M.B.'s possessed an advantage over destroyers in their ability, when coming on the enemy while he was moving at slow speed, in being able to increase to their maximum and get away before destroyers could be worked up to anything like full speed.

A very good opportunity was afforded from the Dunkirk base to compare them with the old small French torpedo boats. These boats were 120 ft. in length with very little freeboard, and their maximum speed of something over 20 instead of about 35 knots made them too slow to run in close to Zeebrugge and Ostend with any chance of getting away, and in rough weather, in spite of their much greater dimensions, they were apparently much worse sea boats then the C.M.B.'s.

Mine-laying.—Owing to their shallow draught and high speed they were able to lay mines in positions which were impossible for other craft, and very useful only responsible for the smoke screen, which they made by the employment of chlor-sulphonic acid in their exhaust (this operation being necessarily carried out ahead of the blocking vessels), but they also marked certain positions with flares to indicate the right turning points for the blocking ships. Two of them entered the harbour in the early stage of the operation to torpedo a vessel alongside the Mole, whilst others were fitted with Stokes trench mortars to throw bombs over the Mole on to the aeroplane sheds.

In the second action at Ostend, when the Vindictive was successfully placed in position, two C.M.B.'s were specially told off to torpedo the ends of the piers to put the guns on them out of action. While others made a smoke screen one of them went in ahead of the Vindictive firing Verey lights to indicate the exact position of the entrance.

It is remarkable that, with one exception, all the C.M.B.'s which took part in the blocking action succeeded in getting away, although they were in many cases very battered and war-worn, with numerous officers and men wounded.

An interesting illustration of the strength of the boats' hulls occurred in the Ostend attack. A torpedo fired from one of them apparently struck something and exploded close under the stern of the boat, and she was actually lifted by the explosion a good many feet. The after-part of the hull was permanently deformed some inches, but was in no way fractured, but a good many of the pipe connections, including the circulating water inlets, were broken, and the crew naturally had a severe shaking. They were nevertheless able to run their boat out of action and to pick up another vessel, which towed them back to Dover. It would seem possible that the fact of the hull being so little in the water contributed to its immunity from damage, but it certainly seems remarkable that the boat should have survived.

Comparison between Second-Class Torpedo-Boat and 55-Ft. Coastal Motor-Boat.

	Second-Class Torpedo Boat, 1880–1890.	C.M.B., 1915–1920.
Length	63 ft. 0 in.	55 ft. 0 in.
Beam	7 ft. 6 in.	11 ft. 0 in.
Speed, measured mile	17·3 knots	40·4 knots
Speed, on 2 hours' run	15 knots	38 knots
Horse-power	170	750
Displacement:		
Hull, fittings and torpedo gear ...	5·16 tons	5·5 tons
Machinery, including fuel tanks and electric plant in C.M.B.	5·36 tons	4·1 tons
Armament (two torpedoes)	0·8 (14 in.)	1·27 (18 in.)
Fuel	1·00 ton*	0·97 ton†
Crew	0·57 (8)	0·36 (5)
	12·89 tons	12·20 tons

* Fuel sufficient for 4 hours' steaming.
† Fuel sufficient for 5 hours' steaming.
See also Figs. 7 and 8 (Plate XXVI).

It has been already stated that the original proposal to attack the German bases was not carried out, but numerous reconnaissances were made by the 40-footers carried by the light cruisers, and it was proved that they could be hoisted out and under way very quickly. Beyond some successful attacks on auxiliary craft there is nothing to record. One interesting action between them and some German aeroplanes took place. Two photographs from one of the attacking aeroplanes showing the action came into British hands and are reproduced in Figs. 10 and 11, opposite. In this particular instance the aeroplanes undoubtedly came off best, and many of the crews being wounded and some of the boats sunk, it was not possible for the boats to get away. Having drifted into Dutch territorial waters they were eventually interned; but it must not be forgotten that this action between C.M.B.'s and aircraft was in broad daylight, it being generally recognised that, unless there is some special reason, the small torpedo boat should always attack at night.

Operations were carried out on the Caspian Sea, the Archangel front and in the Baltic, the most interesting of which was the successful attack by Lieutenant Agar on the Oleg, the guard-ship outside Kronstadt and the subsequent action when an attack was made on the vessels inside Kronstadt Harbour and the Pamiat Azov, the Andrei Pervozvanni and the Petropavlovsk were all torpedoed and sunk (Fig. 12). Limitations of space make it impossible to describe these operations in the present paper.

The authors' endeavour has been to give some acount of the revival of the employment of the small torpedo boat in the British Navy, but they feel that some reference should be made to the boats of similar dimensions of slower speeds which were built and employed in the Adriatic by the Italian Navy. An account of them, and the principal success achieved by Commander Rizzo when he torpedoed and sunk the battleship St. Itzvan, was given by Captain De Villarey in a lecture at the Royal United Service Institution in 1919.

ENGINEERING IN DENMARK.—The Burmeister and Wain Shipyard has published its report for last year, which, in spite of adverse circumstances, appears to be quite satisfactory, inasmuch as the shareholders receive a dividend of 10 per cent. and an additional bonus of 5 per cent. The surplus for the year was 1,843,521 kronen, with an available balance from 1921 of 1,021,365 kronen. A sum of 1,000,000 kronen is added to the reserve fund and 100,000 kronen to the workmen's aid fund. Employment has been moderate, more especially in the shipyard, the foundry, the steel works and the heavy smithy. The machine shops, on the other hand, have been well employed. German competition has made itself keenly felt both as regards repair work and new contracts, but, notwithstanding higher prices, several Danish owners have placed their orders with the company for repairs and other work. The shortage in the Baltic traffic continues to make itself felt in the repair department. Only three new vessels were delivered during last year and contracts for new vessels are few and at very low prices. There are prospects of good employment in the machinery shops, and of improvement as regards the foundry and smithy. In the matter of shipbuilding it is impossible to prophesy anything.

THE S.H.D. AUTOMATIC UNIVERSAL TOOL-GRINDING MACHINE.

CONSTRUCTED BY THE SOCIÉTÉ ANONYME DES ANCIENS ETABLISSEMENTS HOTCHKISS ET CIE., ST. DENIS, PARIS.

Fig. 1.

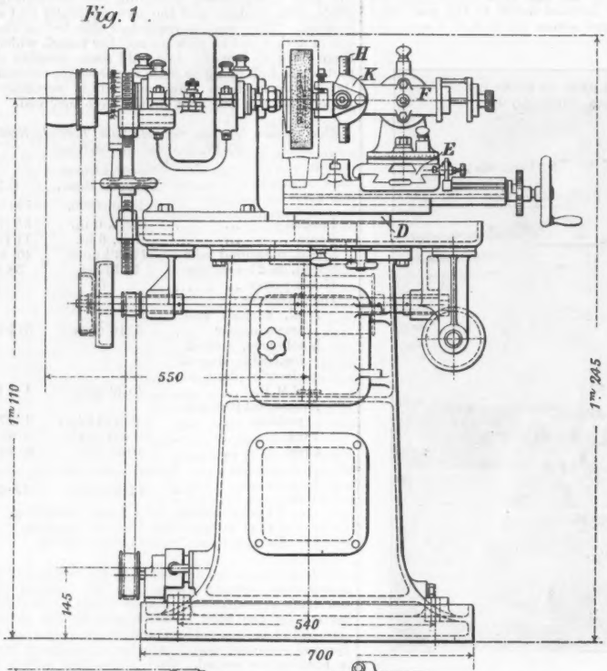


Fig. 3.

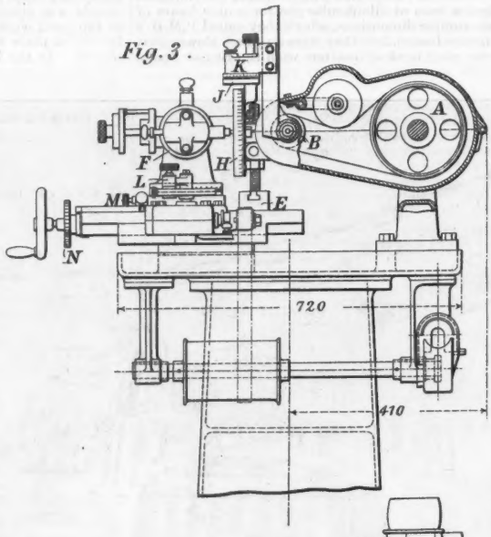


Fig. 2.

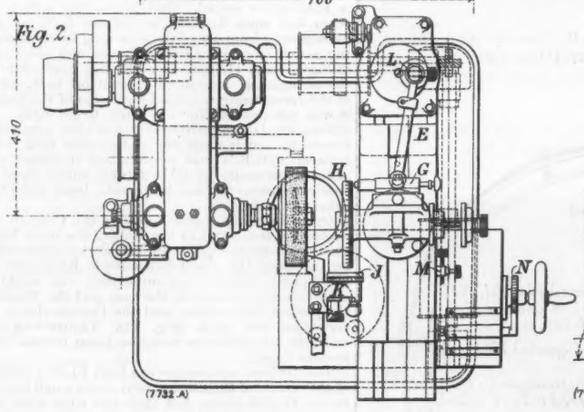


Fig. 4.

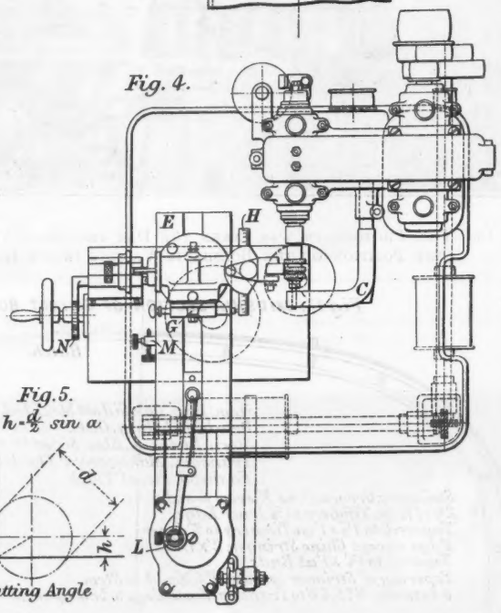
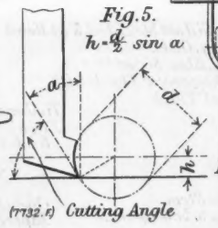


Fig. 5.



WE illustrate in Figs. 1 to 5 and in the views Fig. 6 to 9 the S.H.D. automatic tool grinding machine, designed during the war and built in large numbers by the Société des Anciens Etablissements Hotchkiss et Cie, of St. Denis, Paris. The machine is arranged to be driven either from an overhead shaft, or by an electric motor. In the first case it has only one driving pulley, the overhead gear giving two different speeds. When the drive is by an electric motor a stepped pulley is provided. The machine is given the higher or lower speed according to the type of grinding wheel used. The carborundum grinding wheels are of two patterns, a larger cup wheel, 200 mm. (8 in.) in diameter, for grinding at the lower speed tools having a flat top face, and a series of smaller wheels mounted together, for grinding curved lip tools, these wheels being generally three in series, 50 mm. (2 in.) in diameter, and revolving at the higher speed. Figs. 1 and 2 are an elevation and plan of the machine equipped with the larger grinding wheel; Figs. 3 and 4 side elevation, and the corresponding plan of the same machine equipped with the smaller grinding wheel set.

The drive is transmitted to the grinding wheel shaft by means of the pulley A, driving the pulley B by a belt, which is enclosed in a casing and provided with a jockey pulley. The grinding wheel shaft is carried in long brass bearings carefully lubricated and adjustable for wear by means of nuts at each end. The grinding wheel spindle is fitted at the end of the grinding wheel shaft, and in order to maintain alignment the end is supported by a steady arm C fitted to the machine frame as shown in Fig. 4. Owing to the very great variety of tool shapes which has to be dealt with, and the accurate grinding of the cutting edges, front rake, clearance angle, &c., which has to be provided for, it is necessary to arrange means for shifting the tool in every direction with reference to the grinding wheel. The actual grinding calls for two actions, a reciprocating motion and a progressive feed of the tool against the cutting face of the grinding wheel. In the S.H.D. machine these motions of the tool and its positions relatively to the wheel are obtained by means of a series of tool slides and supports. The tool is mounted in a compound slide, carried on a pivotted support D which can rotate round a vertical centre. The lower transverse slide travels on a guide on the pivotted support D and is utilized for bringing the tool against, or removing it from, the grinding wheel. The slide is operated either by the handwheel, shown in Figs. 1 to 4, or by a power-driven ratchet. The upper longitudinal slide E can be given a reciprocating action with reference to the surface of the grinding wheel, and supports the tool-carrier saddle; this can be swung round a vertical axis and can also be given a forward and backward motion relatively to the grinding wheel, also a reciprocating movement parallel with the wheel surface. The tool-carrier support has a circular base which rests on a circular plate fitted to the upper slide E, on which it can be locked by a nut. When this nut is unscrewed the tool-carrier support is free to swing round the vertical axis. The vertical part of the support carries the sleeves F and G. Through the sleeve F runs a spindle fitted at its end with a large indexing plate H that can be revolved both round the horizontal axis of the tool-carrier saddle and round the horizontal axis of the sleeve F which is at right angles to the preceding. The sleeve G carries a spring operated detent which locks the plate H in position. The latter is fitted with the second indicating plate J on which the tool-holder K can be adjusted and held by means of a bolt forming the axis on which K rotates and a clamp for it. When this latter is unscrewed the tool-holder can rotate freely; the tool itself is held fast in jaws. For insuring the automatic reciprocating motion, the slide E is connected by means of a rod to the eccentric L, the rotation of which is derived from a small belt-driven pulley shown in the plans Figs. 2 and 4, in which the corresponding shafting is also illustrated. The feed of the tool against the wheel is given by the lower transverse slide and for this the automatic reciprocating action of the slide E is utilised, this latter slide being provided with an adjustable stop M which acts upon the ratchet wheel N.

By these means, the various slides can be given the following motions and the adjustments made: (1) Swinging in a horizontal plane of all the saddles and of the tool-holder support with a view to give the

THE S.H.D. AUTOMATIC UNIVERSAL TOOL-GRINDING MACHINE.

CONSTRUCTED BY THE SOCIÉTÉ ANONYME DES ANCIENS ETABLISSEMENTS HOTCHKISS ET CIE., ST. DENIS, PARIS.

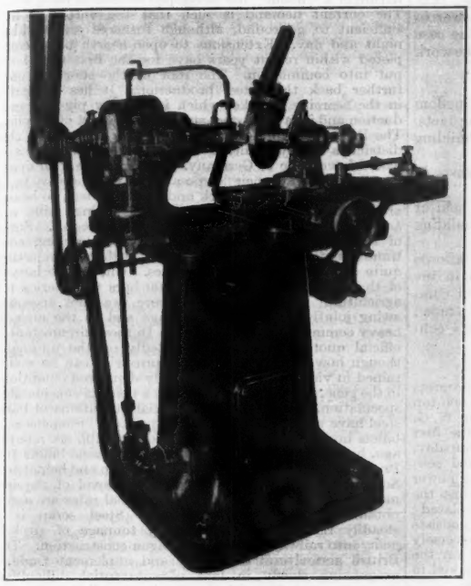


FIG. 6. GRINDING THE CONCAVE TOP FACE OF A PLANING TOOL.

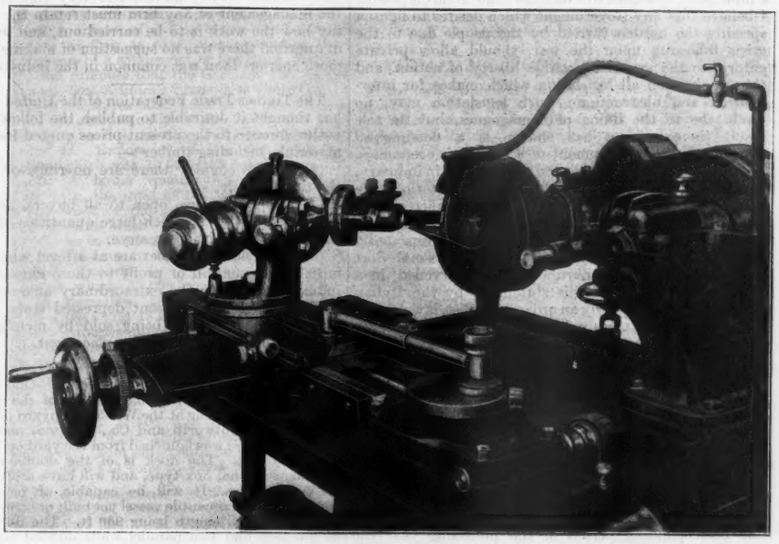


FIG. 7. GRINDING THE FACE OF A SCREW-CUTTING TOOL AT 60 DEG.

FIG. 8. GRINDING A CURVED-FACE TOOL.

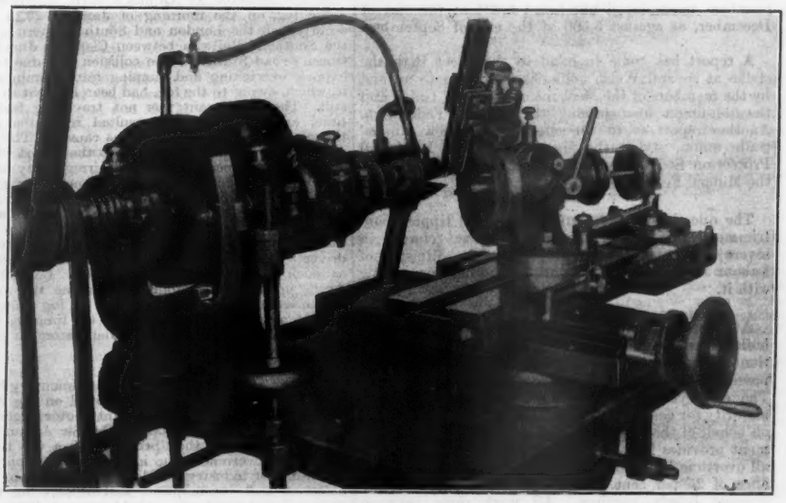


FIG. 9. GRINDING A CONCAVE TOP FACE ON A LATHE TOOL.

latter the required position, according as the small grinding wheels are used, or the larger one. (2) Traversing for the gradual forward feed of the tool against the wheel surface and its withdrawal after the required amount of grinding has taken place, and (3) Reciprocating longitudinal sliding action of the tool with reference to the wheel, combined with the action under (2). (4) Angular orientation in a horizontal plane given by the tool-carrier support on its circular base; this is used for the top rake of flat top-face tools. In the case of concave top-face tools, the top rake is given by the small wheels themselves. (5) Angular orientation in the plane formed by the indexing plate H, by the rotation of this latter, this orientation corresponding to the side cutting angle of the nose of the tool with respect to the tool shank. (6) Angular orientation in a vertical plane of the vertical part of the tool-carrier support, this being resorted to in special cases only and not for normal types of tools. (7) Angular orientation of the tool-holder proper K on the circular base J of the plate H, this corresponding to the side angle. By means of beach marks, adjusting holes, and a table of references which gives the outline of 19 different cutting angles of tools for turning, facing, screw-cutting steel, cast iron, brass, &c., together with the corresponding marks on the machine, the grinding wheels to be used, and the required angles, any of these tools—each of which is referred to separately in the table—can be readily inserted in the machine, and this rapidly adjusted for the grinding work to be done.

The views, Figs. 6 to 9, illustrate grinding a curved lip planing tool; the grinding at 60 deg. of the face of a screw-cutting tool; the grinding of a curved face tool, and the grinding of a curved top face on a lathe tool, the tool support being slightly turned to give a better view of the curved tool face. In order that a tool, whatever the length of its shank, may be placed readily on the machine, an abutment shown in Fig. 8 is provided, which can be shifted back when the tool is clamped. The height of the abutment remains the same, and in order that concave tools may be accurately ground whatever their cutting angle and the grinding wheel diameter, it is necessary that the height of the wheel axis be variable. The diagram, Fig. 5, shows the relation existing between the height h of the wheel axis, the angle a and the diameter d of the wheel. The different values of h are shown in a table supplied with the machine, and this can be adjusted to suit by means of a graduated dial which can be seen in Fig. 9. The machine can easily be adjusted also for grinding milling cutters, reamers, screw taps and drills.

THE MILAN SAMPLE FAIR.—This fair is to be held from April 12 to 27, and particulars concerning it can be obtained from the Italian State Railways and State Tourist Department, 12, Waterloo-place, Regent-street, S.W. 1.

THE BRITISH ELECTRICAL AND ALLIED MANUFACTURERS' ASSOCIATION.—The annual general meeting of this association was held recently in London, Mr. B. Longbottom, chairman of the council occupying the chair. After the formal business had been concluded, the chairman stated, with regard to the British Empire Exhibition, 1924, that the organising of the Electrical and Allied Engineering Section, which was in the charge of the association, had made excellent progress. In the matter of the World Power Conference, as far as this country was concerned, a committee was being formed to organise the Engineering Section, and representatives had already been nominated by the Institutions of Civil Engineers, and of Mechanical Engineers. The other activities of the association were also reviewed, and the report for the past year was adopted.

INDUSTRIAL NOTES.

THE Belgian Journal *L'Echo de la Bourse* reports and approves the following statements recently made by Mr. Mussolini: "The State should give up economic enterprises, especially those that are in the nature of a monopoly, in regard to which the State is incompetent. I believe that any Government which desires to lighten speedily the burden carried by the people due to the crisis following upon the war, should allow private enterprise the greatest possible liberty of action, and should abandon all legislation which makes for intervention and obstruction; such legislation may, no doubt, be to the liking of demagogues, but its sole result—as experience has shown—is a detrimental effect upon the development of a country's economics. . . . I do not think that the forces which in industry, agriculture, commerce, banking, transportation are styled 'capitalism,' are shortly to fall to pieces, contrary to what has been asserted by certain theorists, advocates of socialistic extremes. It has repeatedly been proved that when free initiative and personal effort have been slighted, bankruptcy has supervened in a very short period." This statement by the Italian Prime Minister, formerly an ardent socialist, is welcome; it confirms the news which is published in other quarters to the effect that a number of Italian State monopolies are to be given over to private enterprise.

The fourth quarterly report, from October 2 to December 30, now issued by the Associated Blacksmiths' and Ironworkers' Society, states that the total income for the quarter amounted to 34,187*l.* 3*s.* 4½*d.*, including the sum of 27,944*l.* 14*s.* from the Ministry of Labour, the refund for the payment of State Unemployment, Dependents' Benefits and Management Expenses. The income from contributions was 4,126*l.* 1*s.* 2*d.* For the corresponding period of the preceding year the contributions were 7,830*l.* 8*s.* 4*d.* The total expenditure amounted to 34,914*l.* 17*s.* 3½*d.*, which includes 28,923*l.* 5*s.* 9*d.* State Unemployment, Dependents' Benefit and State Management Expenses. The members unemployed numbered 5,294 at the end of December, as against 5,500 at the end of September.

A report has come to hand to the effect that the strike at several Welsh collieries is coming to an end by the members of the Mechanical Workers' Union and the non-union men joining the Miners' Federation. Another report is to the effect that a new miners' trade union, styled the Midland Counties Industrial Protection Society, has been formed in opposition to the Miners' Federation

The question of the South Wales coal tippers' and trimmers' third shift, to which we have referred in several issues, is not yet settled. The Ministry of Labour has appointed a Court of Inquiry for dealing with it.

At a meeting held last week-end in London of shipbuilding employers and representatives of the Federation of Engineering and Shipbuilding Trades, the proposed overtime and nightshift agreement was discussed. The employers were told that the ballot showed a majority for accepting the agreement, which was signed on behalf of the employers and operatives. The agreement provides for the payment of time and a half for all overtime by time workers, and an additional allowance of 25 per cent. to piece workers, based on the average hourly earnings. All work done between midnight Saturday and midnight Sunday is to be paid for at double rates to time workers and an additional 50 per cent. to piece workers. Night shift work is to be paid for at an additional rate of 66 per cent. and to piece workers at an additional 25 per cent. The agreement is to remain in force for three years, and to be terminable by either party giving six months' notice in writing. The Boilermakers' Society and other unions although forming part of the Federation, did not take part in the ballot, and stated that they would not be bound by the ballot result. Dealing with this subject, the *Liverpool Daily Post* states that "in the aggregate the vote was a small one. . . . The apathy of members of trade unions in regard to voting even on vital questions affecting their wages and conditions of work is becoming a serious matter, and is going far to weaken the trade union in reference to collective bargaining. In all the ballots taken on wage agreements and shop conditions in both the engineering and the shipbuilding industries during the past two years, less than half the members have taken the trouble to record their votes, and on each occasion the voting becomes smaller." We have frequently made comments to the same effect.

A lock-out affecting 30,000 operatives in the Dundee jute trade was declared last week-end. The dispute originated at Messrs. Cox Brothers' Camperdown Works on the question of double spinning. This, Messrs. Cox held, was in conformity with the general practice of the trade, and with the practice in other departments of their own works; but the Jute and Flax Workers' Union protested. The Employers' Association, after full consideration, stated that they saw no reason why objection should be taken to Messrs. Cox's action. They added, and very rightly so, that the management of any firm must retain the power to say how the work is to be carried out, and in the case in question there was no suggestion of making the work more onerous than was common in the industry.

The Timber Trade Federation of the United Kingdom has thought it desirable to publish the following facts, with reference to the present prices quoted for building materials, including timber:—

(1) In this country there are no rings or trusts in the timber trade.

(2) Public auctions, open to all buyers, are held at least fortnightly, at which large quantities of building timber are sold without reserve.

(3) The prices of timber are at a level which affords only a bare margin of profit to those engaged in the industry, owing to the extraordinary amount of competition due to the present depressed state of trade; indeed, timber is now being sold by merchants considerably under the cost of replacement.

FLOATING DOCK FOR SOUTHAMPTON.—Good progress has been made with the construction of the 60,000-ton floating dock building at the Walker Shipyard of Sir W. G. Armstrong, Whitworth and Co., Limited, and the first section (No. IV) was launched from the yard on Thursday, the 22nd inst. The dock is of the double-sided self-docking sectional box type, and will have a lifting power of 60,000 tons. It will be capable of receiving the largest war or mercantile vessel yet built or contemplated; its total overall length being 960 ft. The dock consists of pontoon and two parallel walls divided transversely into seven sections. The first plates were laid on the blocks on November 22, and the total weight worked in up to the present date is approximately 8,000 tons.

THE COLLISION AT QUEEN'S-ROAD, LONDON.—In a dense fog, on the morning of January 22, a collision occurred on the London and South Western section of the Southern Railway between Clapham Junction and Queen's-road Station. The collision was due to a boat express overtaking and running into a train ahead of it, which, owing to the fog, had been brought to a standstill. The boat train was not travelling fast at the time, and little damage resulted from the collision, though a great deal of delay was caused. The accident appeared to be due, according to the report of Colonel J. W. Pringle, recently issued, to irregularity of manual signalling by a fog signalman stationed in a pit in the 6-ft. way at Queen's-road West up distant signal. This man failed to make use of either flags or lamp, and when the boat train approached slowly, uttered no warning but held up one hand. This signal was mistaken by the driver as a caution signal only, and it was acted upon as such with the result described. Colonel Pringle dwells upon the desirability of making the method of transmission of signals to drivers in fog more reliable than at present, and suggests that the time has probably come for extending the use of detonators to particular signal directions.

MOTOR CAR TAXATION.—The Parliamentary Secretary to the Ministry of Transport received on the 23rd inst. a deputation from the important motor organisations. The deputation was introduced by Sir Arthur Stanley, who explained that their primary object was to impress upon the Government the importance to motorists and to the motor industry of adopting a system of taxation based on fuel consumption, and of securing that this change should be introduced by January 1, 1924. Colonel J. A. Cole, President of the Society of Motor Manufacturers and Traders, stated that the present system of taxation was affecting design of cars with a result detrimental to the export trade of the country. Mr. Charles McWhirter, speaking for the Automobile Association and Motor Union, said that the private motor users of the country felt that the present tax was unjust, and whatever might be the findings of the Departmental Committee, would press for its alteration. Colonel Ashley, in reply, stated that he was glad of the opportunity of removing any impression, if it existed, that either he or his department were opposed in principle to a tax on motor fuel. A representative committee had been appointed and was examining the question, and it was naturally impossible for him to express any views on merits until he received the report. He assumed that the points which had been made by members of the deputation had also been put to the committee. As regards the inquiry itself, he had received the following unanimous resolution, which was passed by the Committee on Tuesday, the 20th inst.: "That this committee desires to express its entire confidence in Sir Henry Maybury as its chairman, and in Mr. Pool Godsell, as its secretary, in their conduct of the inquiry." He had consulted the Chancellor of the Exchequer and he regretted to state that it would not be possible now for the report of the committee to be received in time for consideration in connection with the introduction of the Budget this year. It must be remembered that very wide interests were affected, and it was only reasonable, where an inquiry into a change of taxation was held, that all parties concerned should be given an opportunity of putting forward their views.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The advent of Easter finds conditions very uneven in the engineering and steel trades, but on the whole order books are in a much healthier state than was the case six months ago. Something in the nature of a "boom" has developed in mild or basic steel. The current demand is such that the output is not sufficient to go round, although furnaces are working night and day. Extensions to open-hearth plant completed within recent years have for the first time been put into commission. The root of the shortage goes further back than steel production. It lies primarily in the scarcity of coke, which is limiting pig-iron production and is causing steel makers to go short of supplies. The French occupation of the Ruhr has diverted to this district a heavy tonnage of business which normally would have gone to Germany. Steel-makers with open-hearth plant at their disposal are temporarily in a position more or less to pick and choose orders, so heavy are immediate requirements. The rolling mills are accordingly benefiting to a considerable degree. Some of the largest plants in the district are working continuous shifts, day and night, and even then are rejecting quite a fair proportion of inquiries. One of the largest of these, for the supply of 300,000 bars to America for agricultural machinery manufacture, was not accepted owing jointly to the steel shortage and to the already heavy commitments of the mills. In these circumstances official quotations are still markedly on the up-grade, though how long this consistent price-rise can be maintained in view of the comparatively depressed conditions in the general engineering section is a point of considerable speculation. Since last week official quotations of basic steel have risen on an average 1*l.* per ton. Siemens acid billets now stand at 13*l.*, compared with 10*l.* six months ago, hard basic billets 10*l.* 10*s.*, and soft basic billets 10*l.* Prices are very difficult to gauge in pig-iron and hematites. Supplies generally are well below the level of requirements, and owing to the shortage, special rates are easily obtainable for prompt deliveries. Steel scrap is a steadily rising market. A heavy tonnage of steel is going into railway and colliery wagon construction. The British agricultural machinery and implement trade is progressing slowly in face of substantial difficulties. Quite the most disappointing section is still that devoted to the production of high-speed and other special steels. The majority of the departments so concerned are working on very narrow margins of profit, and are only slightly better placed on the average than they were six months ago. Orders for saws, files, and engineers' tools are scarcely sufficient to pay overhead charges. Unemployed operatives, trained in the manufacture of such implements, have issued an appeal to fellow trade unionists in other branches pointing out the detrimental effect on local employment of the importation of foreign tools.

South Yorkshire Coal Trade.—Apart from house coal, which is a dull market at unchanged rates, the colliery position is uniformly strong, and last week's advances are firmly maintained. Steam hards continue a strong section, though congestion of exports at the docks is hampering delivery. Home requirements reflect the improved condition of the staple steel trades. Collieries are well booked forward in cobbles and nuts, and are holding back a substantial tonnage of slacks to tide themselves over the Easter set-down. Contractors are paying 50*s.* at ovens for export supplies of furnace coke. Quotations:—Best handpicked branch, 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 28*s.* to 30*s.*; Derbyshire best brights, 25*s.* 6*d.* to 27*s.* 6*d.*; Derbyshire best house, 23*s.* to 24*s.* 6*d.*; Derbyshire best large nuts, 20*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best small nuts, 17*s.* to 19*s.*; Yorkshire hards, 22*s.* to 24*s.*; Derbyshire hards, 21*s.* to 23*s.*; rough slacks, 11*s.* to 12*s.* 6*d.*; nutty slacks, 10*s.* to 12*s.*; smalls, 6*s.* to 8*s.*

"ATOMIC PROJECTILES AND THEIR PROPERTIES."—Owing to illness Sir Ernest Rutherford, F.R.S., has had to postpone his concluding lecture on the above subject. Our readers will share our own regret and join us in wishing him a speedy and complete recovery.

OIL ENGINES; ERRATUM.—Messrs. Marshall, Sons and Co., Limited, Gainsborough, whose catalogue of vertical oil engines was noticed on page 384 *ante*, have called our attention to a slight discrepancy in our comments on this catalogue. They do not, as we stated, fit the single-cylinder engines with two flywheels when required for driving electric generators, but employ single flywheels of extra weight. We understand that with the multi-cylinder engines, the cyclic variation is small enough to be negligible, so that the standard flywheel is used whether the engines are required for electric lighting or any other service.

ROYAL INSTITUTION.—The lectures at the Royal Institution after Easter will begin on Tuesday, April 10. On Thursday afternoons, commencing Aptil 12, Dr. A. O. Rankine will give two lectures on the "Transmission of Speech by Light"; Professor MacGregor-Morris three on "Modern Electric Lamps"; Dr. E. G. Coker two on "Engineering Problems Solved by Photoelastic Methods"; and Sir William M. Bayliss on the "Nature of Enzyme Action." The Saturday afternoon lectures will begin on April 14. The Friday evening meetings will be resumed on April 13, when the discourse will be delivered by Dr. W. H. Eccles, on "Studies from a Wireless Laboratory." Succeeding discourses will probably be given by Mr. W. J. S. Lockyer, Mr. C. V. Boys, Professor Soddy, Professor W. A. Bone, Mr. W. M. Mordey, Sir Aston Webb, Professor Lorentz and Miss Joan Evans.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Conditions continue such that business in Cleveland pig-iron is almost impossible. Makers have no iron to offer, having sold fully as far ahead as they care to commit themselves, and second-hands have nothing to dispose of. Thus dealings are confined to transactions in small odd lots that unexpectedly come on the market from time to time. Nominally, No. 1 remains at 130*s.* and No. 3 at 127*s.* 6*d.*, but half-a-crown above these prices is stated to have been paid. No. 4 foundry is 125*s.* and No. 4 forge 120*s.*

Hematite.—The East Coast hematite branch keeps strong. Whilst producers have nothing to sell, merchants have still command of a little iron, and a small business is passing. Nothing under 127*s.* 6*d.* is now named for Nos. 1, 2 and 3, and 130*s.* and more is asked by some sellers. No. 1 hematite is a shilling above mixed Nos.

Ferro-Manganese.—Pressing Continental inquiry for ferro-manganese does not appear to have resulted in business of any moment, orders being very difficult to place. The recognised market price is in the neighbourhood of 17*l.*

Foreign Ore.—Sellers of foreign ore still fail to tempt buyers by low quotations. Users are well placed, having good stocks, and substantial supplies to come in. This month's imports against running contracts are heavy. Best rubio is round about 25*s.* c.i.f. Tees.

Blast-Furnace Coke.—Shortage of Durham blast-furnace coke is more acute than ever, but contracts are being renewed, to some extent, with regular local customers, at 45*s.* delivered, though almost double that figure is obtainable on export account, sellers being desirous to meet urgent needs of ironmasters.

Manufactured Iron and Steel.—Producers of manufactured iron and steel have a lot of work on hand, order books of most firms being such as will keep them well occupied over the next two months. Billets are much sought after, and railway material is selling fairly well. Common iron bars are 12*l.*; iron rivets, 14*l.*; black sheets, 15*l.*; billets (soft), 10*l.*; billets (hard), 10*l.* 5*s.*; packing (parallel), 8*l.* 10*s.*; packing (tapered), 11*l.* 10*s.*; steel boiler plates, 14*l.* 10*s.*; steel ship, bridge and tank plates, 10*l.* 10*s.*; steel angles, 10*l.* to 10*l.* 5*s.*; heavy sections of steel rails, 10*l.* 10*s.*; fish-plates, 14*l.* 10*s.*; and galvanised corrugated sheets, 19*l.* 5*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Prices Advanced.—The past week has not seen any change in the Scottish steel trade position, but it may be responsible for a slowing down of fresh business through the advance made in prices. At the works active conditions still prevail and a good general output is common, so it is unfortunate that another increase in quotations has been found necessary on the part of producers at a time when the outlook had begun to get much brighter. Structural sections have been a good market, but ship plates show little movement. The volume of business on hand will ensure fairly steady running for a month or two, and inquiries at present in the market may result in other orders being booked in the near future. Black sheets are in good demand, both for home and export, and in the latter connection large shipments are being made. The matter of prices was under consideration by the steel-makers last week, and as the cost of production showed a further advance it was decided to increase prices from 10*s.* to 20*s.* per ton. The minimum selling prices are now as follow:—Ship plates, ¾ in. and up, 10*l.* 5*s.* per ton; sections, 7 united inches and up, 10*l.* per ton; and under 7 united inches, 11*l.* per ton, all delivered Glasgow stations. Boiler plates were not altered for the home market, but the minimum export price was raised to 13*l.* per ton, which is now in line with the home quotations.

Malleable Iron Trade.—Quite a fair business is being done in the West of Scotland malleable iron trade and the works are keeping busy. With the cost of construction continuing to rise the outlook for further bookings is not too hopeful, as the price of bar iron has an upward tendency, and makers are not very willing sellers at to-day's quotations. The export trade is exceedingly good.

Scottish Pig-Iron Trade.—A very firm tone is general in the pig-iron trade of Scotland, and active conditions rule all round. The demand for hematite continues quite good, while there is no difficulty in clearing off the output of foundry grades. Bookings are fairly heavy and steady shipments are being made every week. Prices show little change officially, but they are very firm and are really a matter of arrangement at the present time.

Shipments of Scottish Pig-Iron.—The export of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, March 24, amounted to 2,567 tons, of which 2,385 tons went foreign and 182 tons coastwise. For the corresponding week last year the figures were 301 tons foreign, and 256 tons coastwise, a total of 557 tons altogether.

Wages in the Iron Trade.—The following intimation has been made to Messrs. James C. Bishop and Owen Coyle, joint secretaries of the Scottish Manufactured Iron Trade Conciliation and Arbitration Board, by Mr. John M. MacLeod, C.A., Glasgow: "In terms of the remit, I have examined the employers' books for January and February, 1923, and I certify the average net selling price brought out is 10*l.* 16*s.* 11·79*d.*" This means no change in the wages of the workmen of this trade.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday

The Coal Trade.—Owing to the near approach of the holidays coupled with the scarcity of available supplies, business has slackened off. The general inquiry too was not so active, but this was chiefly due to the fact that buyers realised the practical impossibility of securing supplies and confined their attentions to arranging the shipment of cargoes and bunkers previously purchased for vessels with a chance of sailing before the holidays. Prices remained as firm as ever notwithstanding talk about the prospects of a settlement of the Ruhr question with France, and rumours that the Germans had ceased buying. In fact, best Admiralty large was quoted up to 40*s.* and Monmouthshires and best drys at 37*s.* 6*d.* Smalls remained exceptionally scarce with the best steams realising from 30*s.* to 31*s.* and best dry smalls from 25*s.* to 27*s.* 6*d.* Exports of coal last week amounted to 627,000 tons, which was 30,000 tons less than in the previous week. A larger quantity than usual was despatched to Italy, the total of 142,500 tons being the highest for any week of the year, and 37,000 tons in excess of the previous week's shipments. The exports included 34,500 tons to Genoa, 19,000 tons each to Venice and Messina, 16,000 tons to Naples and 14,000 tons to Civita Vecchia. Exports to France amounted to 256,000 tons, of which 59,000 tons went to Rouen, 23,000 tons to Marseilles, 28,000 tons to Bordeaux, 16,000 tons to Algiers and 15,000 tons to Havre. Shipments to South America amounted to 49,400 tons, to Spain 22,000 tons, to Portugal 5,000 tons, to Greece 11,600 tons, to British coaling depots 37,100 tons, to the United States 7,300 tons, and to unclassified destinations 96,100 tons, including 15,825 tons to Hamburg, 6,643 tons to Bremerhaven, 1,069 tons to Stettin, 9,600 tons to Belgium and 31,500 tons to Holland. Coke exports amounted to 8,748 tons, of which 6,312 tons went to Hamburg. Fuel shipments on the other hand were reduced from 6,313 tons to 4,404 tons.

Officers of Local Associations.—At the annual meeting of the South Wales Coal Exporters' Association, held at Cardiff, on Monday, Mr. C. L. Clay, of Messrs. C. L. Clay and Co., Limited, was re-elected chairman for the ensuing year, and Mr. T. P. Cook, of Swansea, vice-chairman. Sir Clifford Cory, Bart., Mr. T. J. Callaghan, Mr. Percy W. Phillips, and Mr. E. Franklin Thomas, were re-elected directors and Sir David R. Llewellyn, Bart., was elected director in succession to Mr. Charles E. Cleeves, who had resigned, and Mr. Ernest Coward was also appointed a director in succession to his father, the late Mr. P. H. Coward. At the annual meeting of the Cardiff and Bristol Channel Pitwood Importer's Association, held at Cardiff yesterday, Mr. H. S. Kelly, of Messrs. Budd and Co., Limited, was elected chairman for the ensuing year, and Mr. M. Ragody, of Messrs. E. Marcesche and Co., vice-chairman.

PERSONAL.—Mr. George Cawley, consulting engineer, 82, Victoria-street, S.W. 1, is retiring after thirty years of consulting practice in Westminster. For over a quarter of a century Mr. Cawley has been connected with Japanese Government and private railways, and has had fifty years' connection with Japan in various forms of service.

MACHINE TOOL AND ENGINEERING EXHIBITION.—The Machine Tool Trades Association are now making arrangements for their third Machine Tool and Engineering Exhibition, which is to be held at Olympia during September of next year. The association have now issued their Exhibitors' Guide, containing all necessary information to intending exhibitors. Members of the association will ballot for positions in October next, and after that any remaining space will be offered to non-members, who, however, will not be allowed to show machine tools, small tools or woodworking machinery. It is also to be noted that no goods of German manufacture may be exhibited. The offices of the association are at 70, Victoria-street, London, S.W. 1.

ELECTRIC MOTOR FOR AERODYNAMIC EXPERIMENTS.—Particulars of an interesting electric motor of small diameter, designed by Mr. E. F. Relf, for mounting inside aeroplane models in wind-tunnel experiments, are given in Reports and Memoranda, No. 778, of the Aeronautical Research Committee. The motor is of the three-phase induction type, with a squirrel-cage rotor, and it was constructed primarily for driving the propeller of a one-fifth scale model of the Bristol fighter aeroplane, in the course of some tests carried out in the 14 ft. by 7 ft. duplex wind tunnel at the National Physical Laboratory. The motor, which measures 5·94 in. in diameter and 12·15 in. in length, excluding the shaft extensions, is capable of developing about 1½ h.p. at speeds ranging between 1,500 and 3,000 r.p.m., when supplied with current of from 25 to 50 cycles per second. The current is generated by a 2 kw. motor alternator set, the motor of which is supplied from a battery of accumulators in order to ensure steady running. The stator stampings of the induction motor, which occupy a length of 6¼ in., are clamped inside a thin steel tube, into the ends of which plates carrying Skefko ball-bearings are screwed, and the rotor, which is 3·33 in. in diameter, is mounted on a shaft 1·18 in. in diameter. The use of this very stiff shaft, and the grinding of the stator and rotor stampings after assembly, has enabled an air gap of only 0·006 in. to be employed, and this has contributed largely to the success of the machine. The power factor at 1½ h.p., it may be mentioned, was found to be 0·88, and the weight of the machine is 59½ lb.

NOTICE OF MEETING.

THE ROYAL SOCIETY OF ARTS.—Friday, April 6, at 4 p.m. Indian Section: "Postal and Telegraph Work in India," by Mr. Geoffrey Rothe Clarke, C.S.I., O.B.E., I.C.S., Director-General of Posts and Telegraphs in India. The Right Hon. Lord Montagu of Beaulieu, K.C.I.E., C.S.I., will preside.

ROYAL METEOROLOGICAL SOCIETY.

THE usual March lecture of this Society was delivered on Wednesday, the 21st inst., at 49, Cromwell-road, South Kensington, by Mr. G. M. B. Dobson, M.A., the subject being "*Characteristics of the Atmosphere up to 200 Km., as Obtained from Observations of Meteors.*" The president of the society, Dr. C. Chree, F.R.S., was in the chair. The following is an abstract of the lecture:

Since the head resistance of a meteor passing through the atmosphere depends on the density of the undisturbed air, the rate of heating and evaporation of the meteor also depend on the air density. It can be shown that nearly all the kinetic energy of the meteor is finally radiated as visible light, and thus observations of a meteor's total brightness and velocity give its mass. Hence from the observed characteristics of meteors it is possible to calculate the density of the air at the height of their appearance and disappearance. The rate of change of density with height will indicate the air temperature. Using the best eye observations published by Mr. W. F. Denning, it is shown that the temperature of the air is about 220 deg. a. (= 63 deg. F.) up to 50 km., thus agreeing with the results of "ballon sondes." Above 60 km. a much higher temperature—about 300 deg. a. (81 deg. F.)—is found, and the density at 100 km. is about 100 times geater than that usually calculated on the assumption of a uniform temperature of 220 deg. a. Three other subsidiary lines of investigation all agree in indicating a high temperature above 60 km. The high temperature found is presumably due to the absorption of solar radiation by the air in addition to terrestrial and atmospheric radiation. This may be due to the presence of ozone which would be formed at great heights by the sun's ultraviolet light. Since the air temperature depends partly on direct solar radiation, a marked annual variation would be expected. Indirect evidence of this has also been found.

CONTRACTS.—Messrs. William Beardmore and Co., Limited, have received an order for 3,358 pairs of wheels and axles for the East Indian Railway Company. This contract is valued at over 130,000*l.*—The Aster Engineering Company, Limited, of Wembley, Middlesex, have recently received an order for a number of petrol engines, which will be direct-coupled to centrifugal pumps for trench drainage in connection with the laying of the new concrete main for the Metropolitan Water Board.

FLYING AND CIVIL AVIATION.—We have received from the Air League of the British Empire a copy of a pamphlet intended to be circulated throughout the primary and secondary schools of the country with the object of acquainting the younger generation with some of the essential features of aviation. This pamphlet is entitled "Facts about Flying and the Civic Uses of Aviation," and it contains notes on the history of flying, an elementary explanation of the flight of an aeroplane, information on learning to fly, air-line organisation, airships, &c. Illustrations of an aeroplane and an airship indicating the names of the principal components are also included. The price of the pamphlet is 2*d.*, and the address of the Air League, who publish it, is 26, George-street, Hanover-square, W. 1.

STAINLESS STEEL.—In the course of a paper which he read on February 22, before the Birmingham Metallurgical Society, Mr. J. H. G. Monypenny said that the general properties of stainless steel and also its resistance to corrosion, were influenced to a considerable extent by the heat-treatment which the steel had undergone, and in order to form a basis for the discussion of these variations the lecturer gave a brief account of the structural changes produced in stainless steel by different forms of heat-treatment. The influence of varying composition, more particularly of carbon content, was next dealt with, and it was emphasised that there were available a whole range of steels, all possessing the property of resistance to corrosion, but differing from each other as mild steel does from file steel. After a short account of the behaviour of the steel at high temperatures, the general question of corrosion was dealt with, also the influence of varying composition and heat-treatment on the resistance of the material to corrosion, correlating this latter with the difference in structure. It was shown that the material has the greatest resistance when hardened and the least when annealed, and that cold work decreased the non-corrodibility to a considerable extent. Finally, the lecturer gave a short account of some of the purposes to which stainless steel has been applied, dealing more particularly with hydraulic and steam plant. Numerous instances were given where the resistance to corrosion, and also to erosion by rapidly-moving liquids or gases, of the steel had led to very considerable economies. Among the examples quoted were rams for hydraulic pumps, hydraulic and steam stop valves, steam trap valves, boiler feed check valves, &c. The results of experiments proving the great resistance of the steel to erosion by a high-pressure steam jet were given.

THE WORKS OF THE BARLOCK TYPEWRITER COMPANY, LTD., BASFORD, NOTTINGHAM.

(*For Description, see page* 392.)

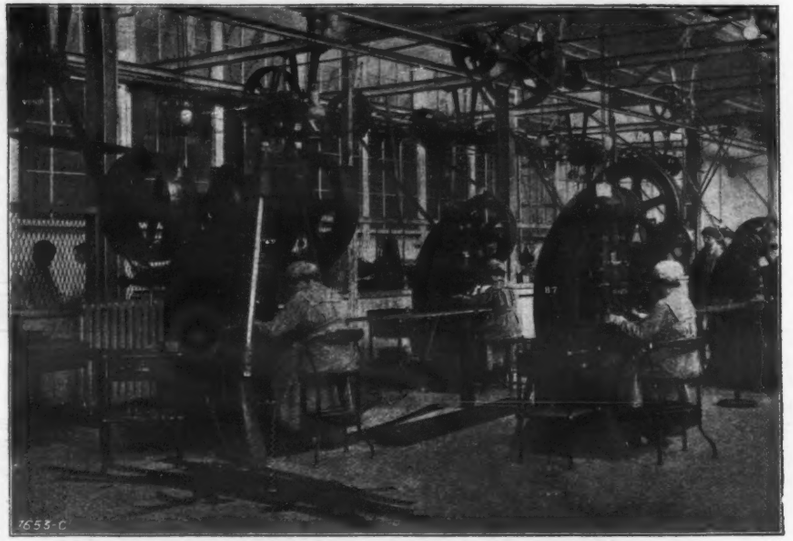


FIG. 7. THE PRESS SHOP.

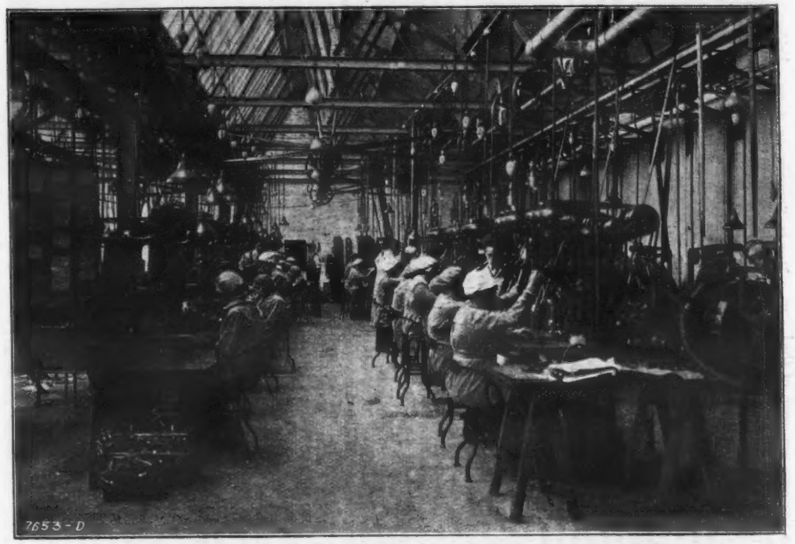


FIG. 8. DRILLING BAY.

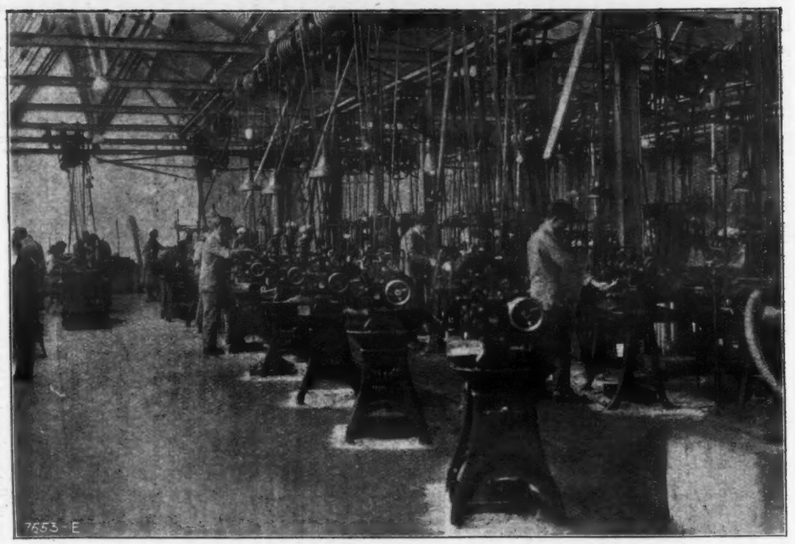


FIG. 9. SMALL MACHINE BAY.

FIG. 10. ASSEMBLY DEPARTMENT.

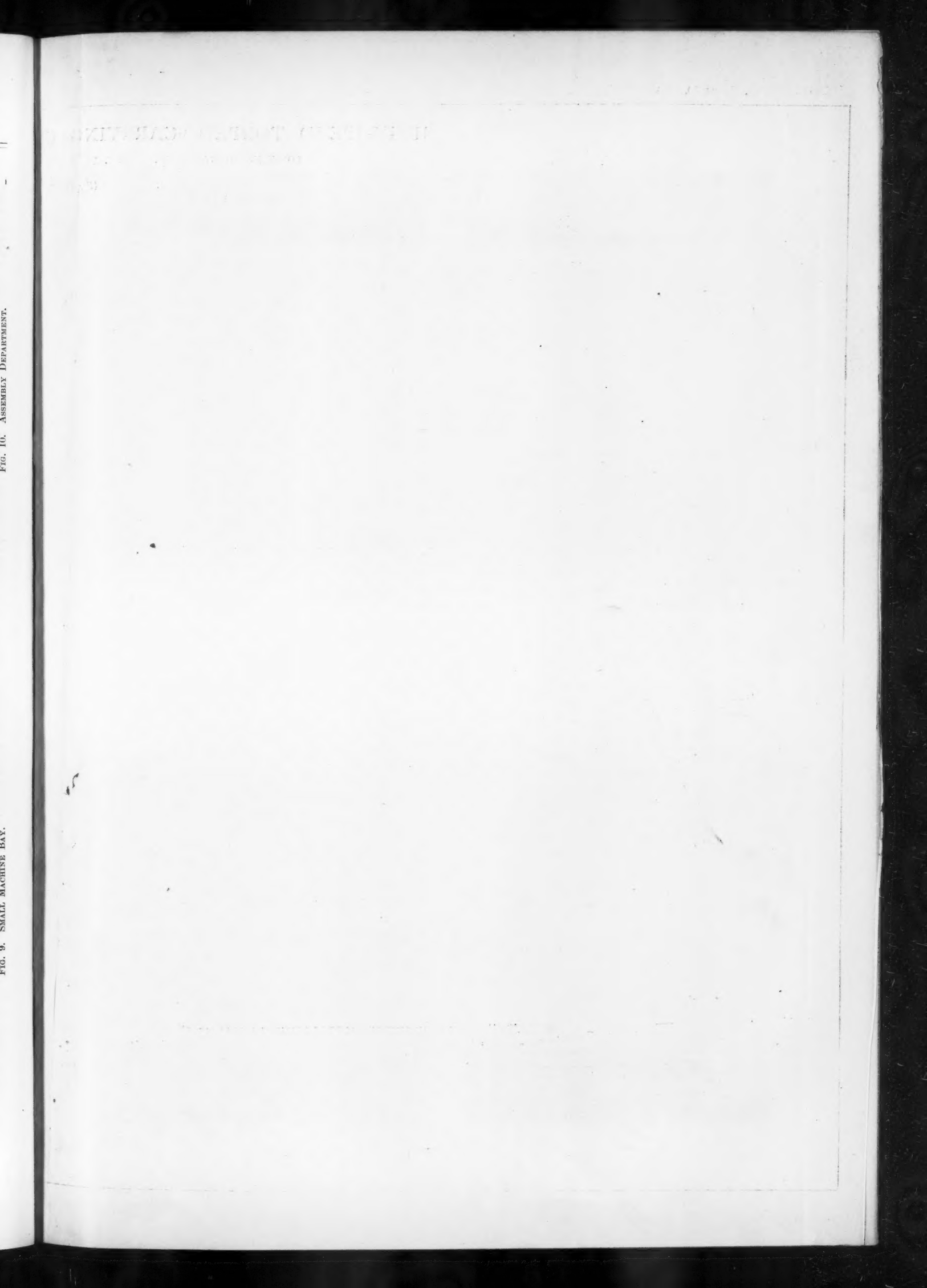


FIG. 9. SMALL MACHINE BAY.

FIG. 10. ASSEMBLY DEPARTMENT.

HIGH-SPEED TORPEDO-CARRYING COSTA

CONSTRUCTED BY MESSRS. JOHN I. THORNYCROFT AND CO.

(For Description, Page 3

Fig. 1. GENERAL ARRANGEMENT VIEWS OF 40-FT COASTAL MOTOR BOAT

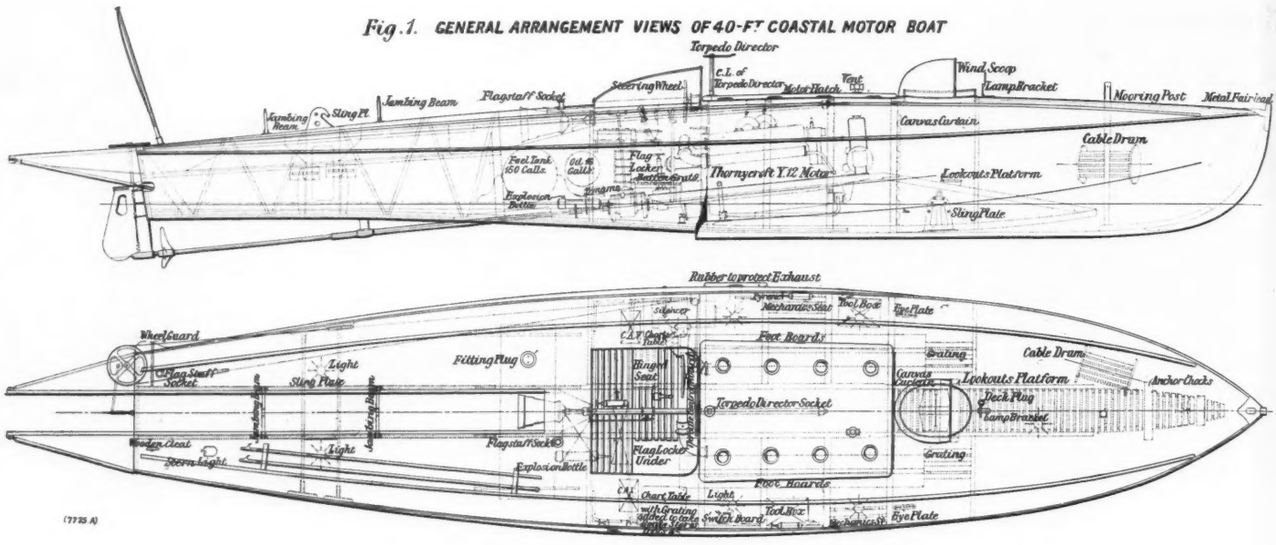


Fig. 2. LIFTING ARRANGEMENTS FOR 40-FT. AND 45-FT. COASTAL MOTOR BOATS.

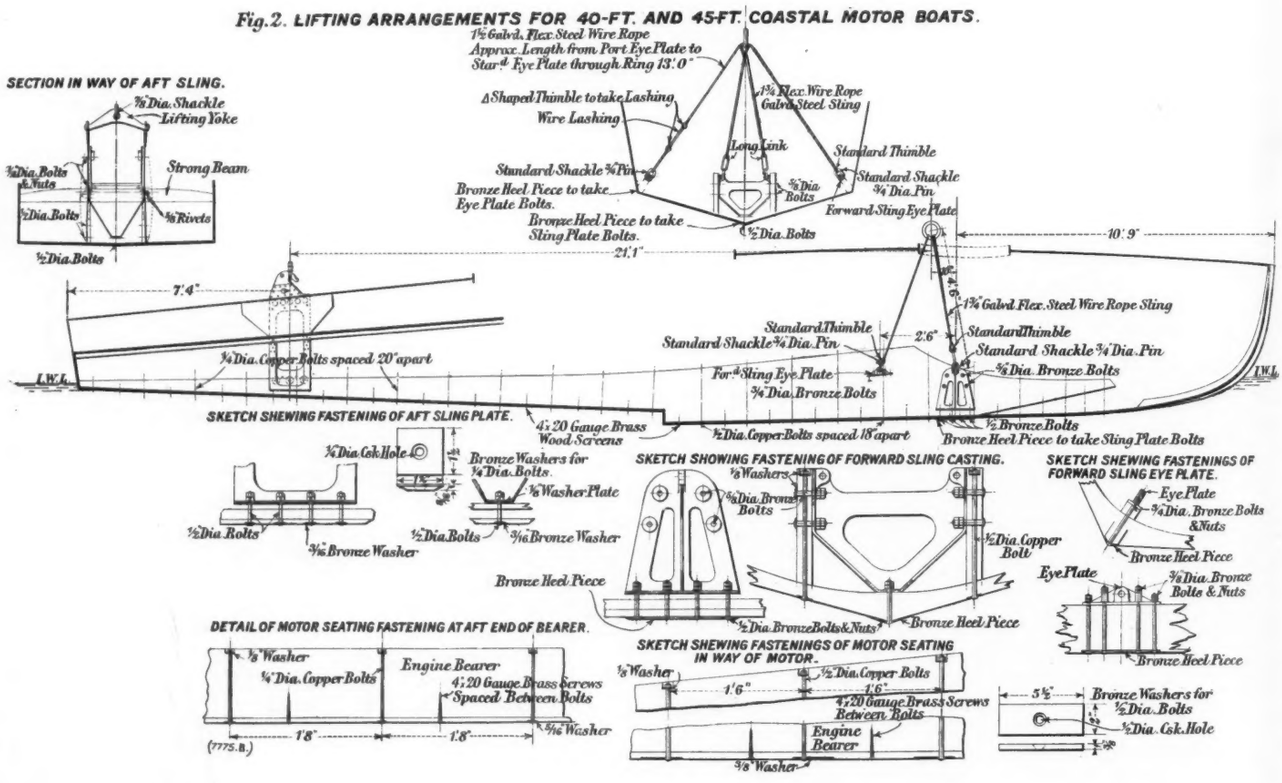
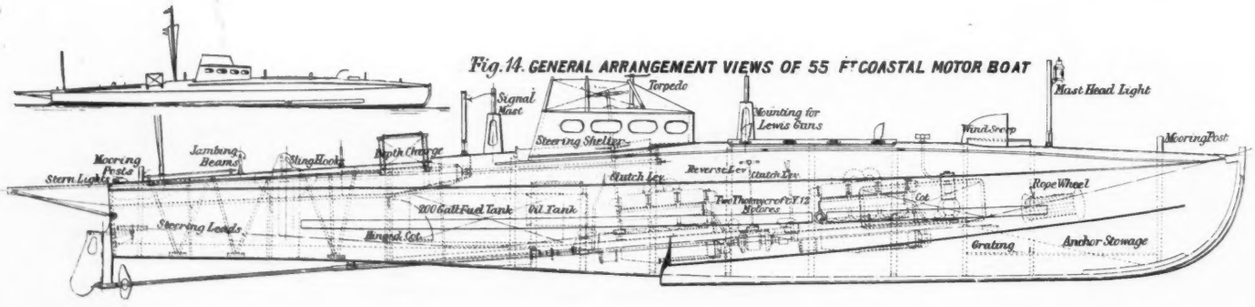

SECTION IN WAY OF AFT SLING.
⅞ Dia. Shackle
Lifting Yoke
Strong Beam
½ Dia. Bolts & Nuts
½ Dia. Bolts
⅝ Rivets
½ Dia. Bolts
7½ Galvd. Flex. Steel Wire Rope
Approx. Length from Port Eye Plate to Starbd. Eye Plate through Ring 13'0"
Δ Shaped Thimble to take Lashing
Wire Lashing
1¾ Flex. Wire Rope Galvd. Steel Sling
Long Link
Standard Thimble
Standard Shackle ¾ Pin
Bronze Heel Piece to take Eye Plate Bolts.
⅝ Dia. Bolts
Standard Shackle ¾ Dia. Pin
Bronze Heel Piece to take Sling Plate Bolts.
½ Dia. Bolts
Forward Sling Eye Plate
21'1"
10'9"
7'4"
1¾ Galvd. Flex. Steel Wire Rope Sling
Standard Thimble
Standard Shackle ¾ Dia. Pin
2'6"
Standard Thimble
Standard Shackle ¾ Dia. Pin
¾ Dia. Copper Bolts spaced 20" apart
For'd Sling Eye Plate
¾ Dia. Bronze Bolts
⅝ Dia. Bronze Bolts
L.W.L.
L.W.L.
SKETCH SHEWING FASTENING OF AFT SLING PLATE.
4's 20 Gauge Brass Wood Screens
½ Dia. Copper Bolts spaced 18" apart
½ Bronze Bolts
Bronze Heel Piece to take Sling Plate Bolts
¼ Dia. Csk. Hole
Bronze Washers for ¼ Dia. Bolts.
⅛ Washer Plate
½ Dia. Rolts
⅜ Bronze Washer
½ Dia. Bolts
⅜ Bronze Washer
SKETCH SHEWING FASTENING OF FORWARD SLING CASTING.
⅛ Washers
⅞ Dia. Bronze Bolts
½ Dia. Copper Bolt
Bronze Heel Piece
½ Dia. Bronze Bolts & Nuts
Bronze Heel Piece
SKETCH SHEWING FASTENINGS OF FORWARD SLING EYE PLATE.
Eye Plate
¾ Dia. Bronze Bolts & Nuts
Bronze Heel Piece
Eye Plate
⅜ Dia. Bronze Bolts & Nuts
Bronze Heel Piece
DETAIL OF MOTOR SEATING FASTENING AT AFT END OF BEARER.
⅛ Washer
¼ Dia. Copper Bolts
Engine Bearer
4's 20 Gauge Brass Screws Spaced Between Bolts
5/16 Washer
(7775.B.)
1'8"
1'8"
SKETCH SHEWING FASTENINGS OF MOTOR SEATING IN WAY OF MOTOR.
⅛ Washer
½ Dia. Copper Bolts
1'6"
1'6"
4's 20 Gauge Brass Screws Between Bolts
Engine Bearer
⅜ Washer
5½"
Bronze Washers for ½ Dia. Bolts
½ Dia. Csk. Hole

Fig. 14. GENERAL ARRANGEMENT VIEWS OF 55 FT COASTAL MOTOR BOAT



G COSTAL MOTOR BOATS IN WARTIME.

ORNYCROFT AND CO., LIMITED, ENGINEERS, SOUTHAMPTON.

Description Page 393.)

Fig.3. RESISTANCE CURVES OF MODELS & E.H.P. AT MAXIMUM SPEED OF ACTUAL BOATS.

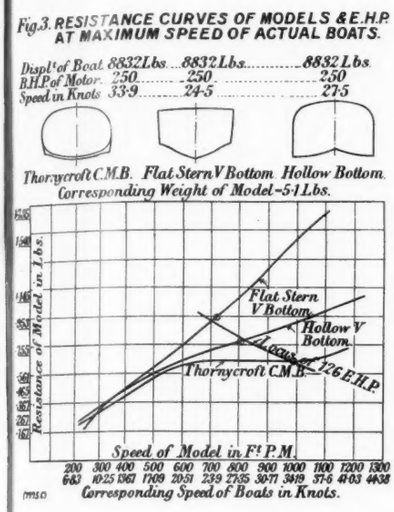

Displt of Boat 8832 Lbs. 8832 Lbs. 8832 Lbs.
B.H.P. of Motor 250 250 250
Speed in Knots 33·9 24·5 27·5
Thornycroft C.M.B. Flat Stern V Bottom Hollow Bottom
Corresponding Weight of Model = 5·4 Lbs.
Resistance of Model in Lbs.
Flat Stern V Bottom
Hollow V Bottom
Thornycroft C.M.B. 276 E.H.P.
Speed of Model in Ft P.M.
200 300 400 500 600 700 800 900 1000 1100 1200 1300
663 1025 1363 1709 2051 2391 2735 3077 3419 3761 4103 4438
Corresponding Speed of Boats in Knots.
(7775 D)

Fig.4. STERN VIEW OF BOAT WITH SPIRAL PROPELLER FOR JUMPING WIRES.

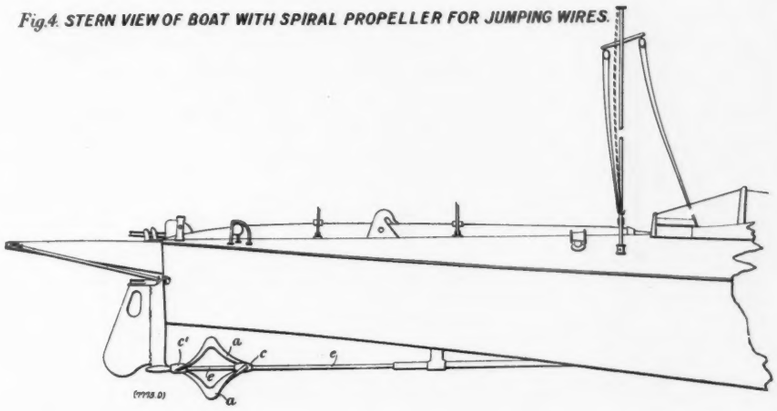


Fig.7. 63-FT. TORPEDO BOAT CARRYING TORPEDOES IN TROUGHS WITH THORNYCROFT PATENT STEAM RAM IMPULSE GEAR. BUILT FOR THE BRITISH GOVERNMENT IN 1883.

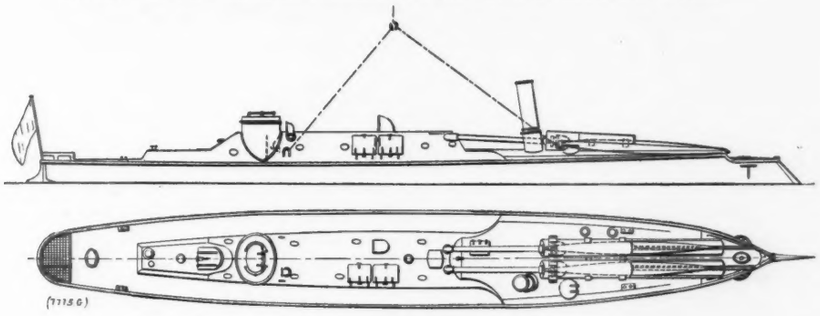


Fig.5. DIAGRAM OF EXPLOSION VESSEL AND RAM.

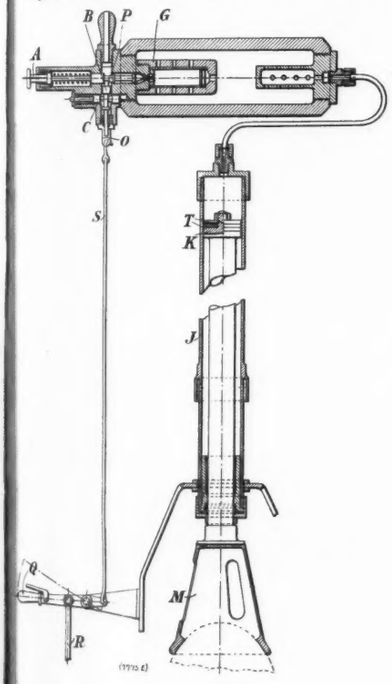


Fig.8. 55 FT THORNYCROFT C.M.B. CARRYING TWO 18 IN. TORPEDOES AS BUILT FOR THE BRITISH GOVERNMENT 1915-1918.

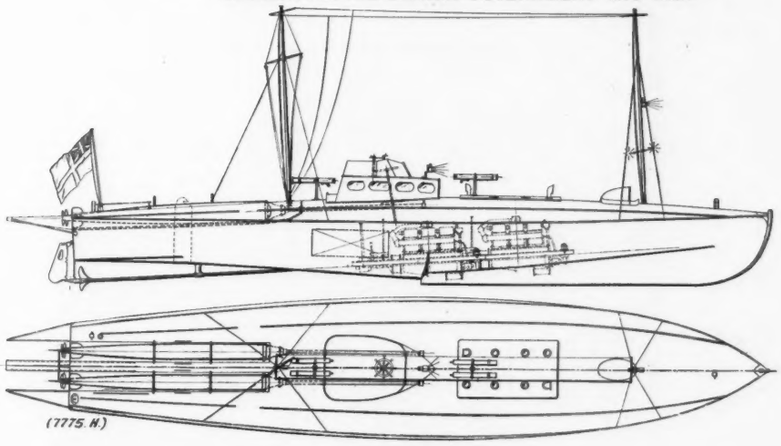
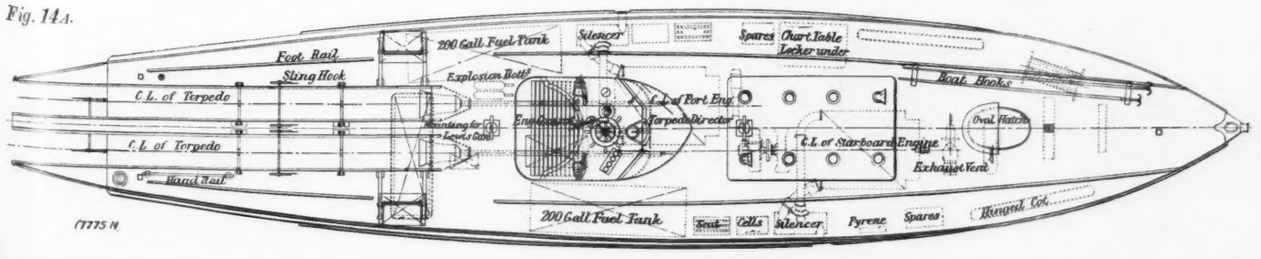


Fig. 14A.



ENGINEERING.

Offices for Publication and Advertisements, and 36, Bedford Street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3663 and 8598 GERRARD

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" may be ordered from any newsagent in town and country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£3	5	0
For Canada—			
Thin paper copies	£2	18	6
Thick paper copies	£3	3	0
For all other places abroad—			
Thin paper copies	£3	3	0
Thick paper copies	£3	7	6

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

When foreign subscriptions are sent by Post Office orders, advice should be sent to the Publisher.

ADVERTISEMENT RATES.

The charge for advertisements classified under the headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. A line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch.

Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Special advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

All accounts are payable to ENGINEERING LTD. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C. 2.

AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Angus and Robertson, Limited, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.

BELGIUM, Brussels: E. F. Satchell, 86, Rue de Tabellion.

CANADA, Toronto, Ont.: Wm. Dawson and Sons, Limited, 87, Queen Street, East.

EGYPT: John Menzies and Co., 12, Hanover-street.

FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Advertisements, Agence Havas, 8, Place de la Bourse.

GLASGOW: William Love.

INDIA: Calcutta: Thacker, Spink and Co., Bombay Thacker and Co., Limited.

ITALY: U. Hoepli, Milan.
Anonima Libraria Italiana, Torino.
And any post office.

LIVERPOOL: Mrs. Taylor, Landing Stages.

MANCHESTER: John Heywood, 143, Deansgate.

NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland and Christchurch.

NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.

ROTTERDAM: H. A. Kramer and Son.

SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Wm. Dawson and Sons (South Africa), Limited, 29 and 31, Long-street, Capetown.

TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston Hobart.

UNITED STATES: For Subscription, New York: W. H. Wiley, 432, Fourth Avenue. For Advertisements: J. S. Allan, 30, Church-street, New York.

CONTENTS.

	PAGE
The Centenary of Sir William Siemens	385
The Nechells Power Station of the Birmingham Corporation (*Illus.*)	385
The Institution of Naval Architects	388
The Manufacture of the Barlock Typewriter (*Illus.*)	392
Coastal Motor Boats ("C.M.B."): Their Design and Service during the War (*Illus.*)	393
The S.H.D. Automatic Universal Tool-Grinding Machine (*Illus.*)	396
Industrial Notes	398
Notes from South Yorkshire	399
Notes from Cleveland and the Northern Counties	399
Notes from the North	399
Notes from the South-West	399
Notices of Meetings	399
Royal Meteorological Society	399
Inventions and Rewards	401
Workmen's Compensation: Agreements to Settle for a Lump Sum	402
Small Quantities	402
Distortion of an Aluminium Crystal during a Tensile Test	403
The Late Sir James Dewar, F.R.S.	403
Notes	404
Literature	405
Books Received	406
Letters to the Editor:—"Turning Piston Rings" (*Illus.*). "The Effect of Repetition Stresses on Materials." "Rotating Discs of Conical Profile" (*Illus.*)	407
The Optical Society	407
Notes on New Books	408
Mechanical Gearing (*Illus.*)	408
The Powering of Motor Ships (*Illus.*)	412
Electric Ship Propulsion (*Illus.*)	414
ENGINEERING Patent Record (*Illus.*)	417

Two-Page Plate.—HIGH-SPEED TORPEDO-CARRYING COASTAL MOTOR BOATS IN WARTIME.

ENGINEERING.

FRIDAY, MARCH 30, 1923.

INVENTIONS AND REWARDS.

THOSE who take pleasure in reflecting upon the injustices of the world often seek to illustrate their theme by reference to the sad case of the inventor. An inventor, to them, is a man upon whose brain the community depends for every advance in material comfort, but who nevertheless earns little reward for his labours except the derision or at best the kindly tolerance of those who benefit by his genius. The fruits of his mind are appropriated by grasping capitalists or soulless corporations who amass wealth by the exploitation both of the inventor and of the public.

Yet another assumed social injustice is discovered in the fact that such pecuniary rewards as inventive talent may receive are hopelessly ill-assorted with the brilliancy of the inventions. A new kind of bottle-stopper, for example, may make a man a millionaire, while, on the other hand, the inventor of a machine to analyse periodic functions may die unknown and in poverty. It is frequently assumed that the injustice of facts such as these is self-evident. But propositions which appear self-evident are often those which deserve the closest enquiry. Justice is a term which has no definite interpretation, and we can only say that a thing is just or unjust according as it agrees or otherwise with our own particular notions of what is right and proper. Nothing which outrages the sense of justice of the community can endure for very long, and as there is no record since civilisation has existed of inventors as a class holding any more privileged position than they do at present, it may be taken that such rewards as they receive are held to be as proportionate to services rendered, as are the rewards of any other class of the community.

In saying this we do not wish to deny that there are cases of individual hardship to inventors, for there are many instances of such. But that these are greater or relatively more numerous than those which fall to the lot of the rest of mankind we do not believe. Invention, like every other activity of the human race, is subject to certain inexorable laws of economics, the harshness of which is only complained of by those who will not recognise that they are inevitable. The community will only reward an inventor in so far as he confers upon it something which is wanted. This, indeed, is eminently reasonable, for no sensible man will encourage another to render services which do not contribute to his well-being or enjoyment. There may be cases when the community, or the individuals, by reason of defective education, do not know what is for their ultimate good, and thus they may decline to avail themselves of valuable inventions, but as they are the only possible judges the decision can only rest with them. An inventor does not really serve his fellow men by offering something which they will not have, and they are therefore under no obligation to reward him. In other cases their obligation is no greater than the benefit they derive from his invention. If a considerable proportion of the population feel an urgent need for a new shape of hat, the man who devises an acceptable one is likely to get a higher reward than if he had invented a new calculating machine. Some people may consider that a calculating machine is a much more valuable invention than a new hat, and that it requires a much higher order of intelligence for its conception. We do not say that they are wrong, but merely point out that the public cannot reasonably be expected to reward a man more for giving them a calculating machine which they do not want than for providing them with the hat that they do want.

We have assumed, for the sake of argument, that it is the inventor who provides the public with the articles he invents. This is the assumption generally made in discussions of this sort, and the failure to recognise that invention and commerical production are two entirely separate and distinct questions is at the root of much of the confusion of thought which surrounds the subject of invention. A man may invent the most useful and wonderful thing in the world, but so long as the invention remains an idea in his own mind it is of no use to anybody. Even if he publishes it to the world in the form of a patent, or writes a book describing it, it is still of no practical use to the public. They cannot grind corn, or smelt iron or do anything else that the invention may relate to, merely because of the existence of a patent specification or a book. Generally speaking, utility does not exist until someone has devoted much time and labour to the commercial production of some actual machine or apparatus successfully embodying the principle which the inventor thought of. Then, and not until then, can the public reap any advantage from the inventor's thought, and until they can receive such advantage he has no right to expect to gain any financial reward. By this time, however, there is the man or the company who made the invention a practical success and rendered it available to the public to be considered. They also expect a reward for their enterprise. They may have staked vast sums of money and even their commercial existence, in their endeavours to render practical an idea, and such risks can only be undertaken if the reward to be obtained is adequate.

Although an inventor may say that the public would not enjoy certain amenities but for him, he must not forget that it was not he—considered merely as an inventor—who bestowed the benefits. We do not reward the informant who tells us how to get to a certain place, though we willingly pay the cabman who drives us there. It is the latter who has conferred the practical benefit upon us and who has expended skill, time and material in getting us to where we want to be. Similarly it is the firm or group of firms by whose enterprise useful things are made available to us at reasonable prices, who rightly receive a higher reward than the man who first conceived the idea of such things, although his thought may have started the train of events. The facility with which "invention" of a sort is performed is illustrated by the numbers of people who claimed to have invented the military tanks, on the grounds that they had thought that an armoured vehicle progressing by means of caterpillar tracks would be the means of ending the deadlock on the Western Front. It was rightly held that the real credit belonged to the man who put the idea into practical form and produced the familiar lozenge-shaped machine with chains surrounding the whole body, which would almost go anywhere and do anything. It was that machine which enabled our soldiers to break the German

line, and not the hazy visions of the arm-chair inventors.

There are two separate motives which impel men to invent, one being the hope of material reward and the other the purely intellectual pleasure derived from solving a difficult problem. It cannot be denied that the latter motive is the mainspring of an enormous amount of inventive labour, from which it is certain that no pecuniary benefit can ever be derived. There are men, for example, who would spend months or years in an endeavour to discover the singularities of a novel transcendental function, for the sheer pleasure which success would give them. This is invention quite as much as the discovery of a new kind of engine, or of a practical method of utilising the energy of solar radiation. Men who do these things are often quite free from any mercenary motive and they bear no grudge against the world if others turn their discoveries into money. If, on the other hand, a man invents for the sake of getting rich, or, having invented, if he seeks to derive wealth from his invention, he must fulfil the conditions necessary to the acquirement of wealth. In other words, he must render something available to the public which they, in their turn, are benefited by acquiring. This, moreover, must be done on a sufficiently large scale to ensure him an adequate recompense. As a rule any invention, to be successful in a material sense, must be developed by men with practical manufacturing knowledge and sound business instincts. If the inventor does not possess these characteristics himself and cannot command the services of others who have them, he fails to conform to the elementary condition of commercial success and cannot therefore expect the rewards which are dependent upon such success.

WORKMEN'S COMPENSATION: AGREEMENTS TO SETTLE FOR A LUMP SUM.

THE House of Lords, by their decision in the case of Russell *v.* Rudd, on March 20, 1923, have put an end to some difficult questions as to the effect of agreements to settle claims for workmen's compensation in cases of incapacity, and have overturned a series of decisions of the Court of Appeal extending over the last ten years. The appellant, Russell, was in the employment of a Mr. George Rudd, and in October, 1920, he met with an accident arising out of, and in the course of, his employment, and received injuries. Mr. Rudd did not dispute his liability to pay compensation under the Workmen's Compensation Act, and without entering into any formal agreement he paid Russell 35*s.* a week (the maximum weekly amount of compensation) from the time of the accident until August 13, 1921. He was insured with an insurance company against liability for workmen's compensation, and in June, 1921, an agent of the insurance company called on Russell and told him that in view of a medical report which had been obtained he would no longer receive full compensation, and he proceeded to negotiate with him for a settlement of all claims for a lump sum. Ultimately an agreement was entered into to the effect that Russell agreed to accept, and Mr. Rudd agreed to pay, 75*l.* in full settlement and discharge of all claims in respect of the accident. Mr. Rudd then forwarded to the registrar of the County Court a memorandum of the agreement, and applied to have it recorded under paragraph 9 of the second schedule to the Act. The registrar refused to record it because he considered the sum of 75*l.* inadequate, and he referred the matter to the County Court judge. Meanwhile, Russell, whose compensation had been stopped, filed a request for arbitration, and this came before the judge, together with the application for the recording of the agreement. The judge held that the agreement was an agreement as to the redemption of a weekly payment within paragraph 9 of the second schedule, and that the sum of 75*l.* was inadequate, and he refused to record the memorandum, and in the arbitration proceedings made an award in favour of Russell of 13*s.* 6*d.* a week from August 14, 1921. Mr. Rudd appealed, and the Court of Appeal allowed the appeal and ordered the award of 13*s.* 6*d.* to be set aside and the memorandum of agreement to be recorded. It is necessary to explain why they took this course.

The Workmen's Compensation Act contains a number of provisions regarding agreements for the redemption of weekly payments of compensation by a lump sum. Such agreements do not terminate the employer's liability to continue the weekly payments unless they are registered in the County Court, but the registrar has power to refuse to register them if he thinks the amount to be paid in redemption inadequate. If he refuses to register the agreement the matter goes before the County Court judge, and he has to decide whether it is to be registered or not. The Court of Appeal, however, in the series of decisions to which we have referred, put a somewhat narrow construction on the expression in the Act "an agreement as to the redemption of a weekly payment by a lump sum." They held that where the weekly payments of compensation were running on and the parties merely agreed that the future payments should be redeemed by the payment of a lump sum, that was an agreement as to the redemption of a weekly payment by a lump sum and the provisions of the Act as to registration of such agreements applied; but where there had been no previous agreement for weekly payments, or even where there had been weekly payments but the employer had stopped them and the lump sum was paid not in redemption of future weekly payments which would otherwise have run on but rather as a compromise or settlement of the worker's claims, the agreement was something different from an agreement as to the redemption of a weekly payment, and the provisions of the Act did not apply and the registrar could not refuse to register the agreement. In the present case they held apparently that the agreement was a compromise or settlement and not an agreement for redemption, and that the registrar had no power to refuse to record it.

The House of Lords, by a majority of four to one (Lord Carson dissenting), set aside the judgment of the Court of Appeal and restored that of the County Court judge, and in doing so put an end to the supposed distinction between compromises and agreements for redemption. The Lord Chancellor said that when a workman suffers from incapacity caused by an accident falling within the Act, he becomes *ipso facto* entitled to a weekly payment. Although the amount may not be immediately fixed, it can be fixed in accordance with the Statute; and he considered that an agreement to pay a lump sum in full settlement of all claims was in effect an agreement for the redemption of a weekly payment, and the statutory provisions as to the necessity of registration, and the registrar's power to refuse to register if he thought the amount inadequate, applied.

The Lord Chancellor went much further than this, however, for he held that an attempt to settle a claim of a workman suffering from incapacity, apart from redemption of a weekly payment, would be an attempt to contract out of the Act, and therefore void. The effect of Section 1 (1) of the Act, he said, was to entitle the injured workman to compensation in the form of a weekly payment. The effect of Section 1 (3), so far as material, was that any question as to the amount or duration of compensation under the Act might be settled either by agreement between the employer and the workman or by arbitration. The arbitrator could not, under this sub-section, award compensation in the form of a lump sum, and in his opinion the power to settle by agreement was limited in like manner. The intention of the Act was that a workman who was suffering from total or partial incapacity caused by accident should receive a weekly sum which should be subject to review from time to time but might be redeemed by agreement with the employer, subject to the approval of the agreement by the County Court, *i.e.*, by the registrar or the County Court judge. To substitute for compensation of that character the payment of a lump sum fixed only by agreement between the employer and the workman and free from any examination by the Court was to contract out of the Act and was void.

The result of the judgment seems to be that in future all settlements of claims by an injured workman for compensation will receive effect only if approved by the registrar or the judge of the County Court. In some cases it may be of advantage that the worker should be protected in this way against an unfair settlement, but the power of veto thus given to the registrar or judge takes away what Lord Carson called "the inherent right of compromising legal claims" and may seriously increase the heavy burden which the Workmen's Compensation Acts have imposed on industry.

SMALL QUANTITIES.

THOSE who have had the benefit of a more or less advanced course in mathematics, and at the present time there can be few engineers who have not, will probably remember that during the development of many mathematical processes it is convenient or necessary at a particular stage to expand an expression into terms, some of which are small in value compared with others. The former are termed "small quantities" of the first and higher orders, and in the further stages of the process they are omitted or as the text-books express it "their effect can be neglected." Usually the process remains an algebraic one, but in a few mathematical works the authors proceed to substitute reasonable arithmetical values for the algebraic symbols, and by evaluating the expression both with and without the neglected terms, show the omission of the latter has little or no effect on the result and is justifiable. In applied mathematics, especially in that portion which deals with the strength of beams, shafts, &c., the same procedure is even more necessary for the purpose of obtaining simply expressed relations between the principal quantities to render them of ready application. The results obtained are however generally less correct than those of pure mathematics.

The principle referred to is one which admits of wide application, but judging from current literature, both general and technical, it is either unknown or is but rarely observed. Two instances may be quoted in illustration of this non-observance, but many others will occur to the intelligent reader. The first is taken from an article on coal included in a well-advertised lexicon of general knowledge. Amongst other matters, the article refers at some length to the coal resources of the British Isles and quotes estimates made by two Royal Commissions appointed for the purpose of inquiry. The basis of the estimates of both Commissions was the same, viz., coal seams at least 1 ft. thick and within 4,000 ft. of the earth's surface. Whilst the estimate of the First Commission, appointed in 1866 and reporting in 1871, was 90,207,285,398 tons, that of the second, appointed 1901 and reporting in 1905, was, 100,914,668,167 tons. The article states that between 1870 and 1903 the coal raised weighed 5,694,928,507 tons. The two estimates thus differ by 16 milliards of tons or about 18 per cent. of the smaller. Both sets of figures must have been obtained by mining engineers in the first instance, and seen and discussed by many competent persons, including the Commissioners, before they were embodied in the reports. Many must have been aware of the very approximate nature of such estimates, and the reader is left to conjecture why they were not finally expressed in milliards of tons and the small quantities omitted. So presented, they would have conveyed the same impression and remained as accurate, or inaccurate, as the published figures. The article also includes a tabulated statement showing the detailed estimates of the various coal districts. Some hundreds of figures appear, and although the estimate for the smallest district is about 250 millions, all are expressed to the nearest ton.

The second example is taken from the current number of a leading technical journal, which quotes the tenders received by a municipal authority for an important building operation near London. Eleven tenders were received, the highest being over 31,250*l.* and the lowest 22,500*l.* Of the 11 all except one are expressed in pounds, shillings and pence. For such an important work, necessarily carried out in the open, the weather conditions prevailing during the operations, must exercise an effect which may seriously influence the cost. Other and less obvious causes will also have the

same result, and it is difficult to understand why with these uncertain conditions, tenders involving such amounts are not finally rounded off to the nearest 50*l.* before their presentation.

Many similar instances could be quoted to justify the statement already made as to the general lack of appreciation of the effect and value of small quantities. There is one other which must be mentioned, since it may afford a partial explanation of the other two. Generally with young engineers, fresh from their academic courses and equipped with a full knowledge of many mathematical processes, there exists a great tendency to consider all engineering calculations as mathematically definite and correct. They express their results—stresses in tons per square inch or dimensions in inches, for example—to the second, third or even fourth places of decimals, no attention being given to the underlying fact that the conditions of the problem, forces, lines of action, &c., are not usually definite; the formulæ employed are approximate; the material is not perfect; the different portions of the structure are non-homogeneous and not mathematically perfectly connected; or that the material used may have an elastic limit with a range of 5 to 10 per cent. and an ultimate strength with a range of 10 or 15 per cent. It is perhaps difficult to impress upon a beginner the differences between theory and practice, but unless this is done by his professors whilst still at college, or his seniors when he has entered his profession, the tendency referred to is difficult to check and all sense of proportion is lost.

There is, however, another point of view from which the matter of small quantities can be regarded and which has a more practical and useful application. Turning again to mathematical processes it is very often the case that two expressions are nearly equal, and their difference has to be expressed in small quantities. The latter cannot now be neglected as before since they have now become of some value and importance. These mathematical small quantities are in such an instance, analogous to those small economies in labour and material in engineering work, which thoroughly and systematically studied and adopted result in a very sensible reduction in cost and a lower tender than that of a competitor who does not exercise the same diligence. This is more particularly the case where the tender is concerned with many similar articles or fittings whose manufacture fall under the description of repetition work, but in these days of keen competition such economies cannot be neglected in any type of work. A fairly long experience has convinced us that these small economies are generally overlooked and are not studied as they deserve to be, while on the other hand firms who continuously study to effect them are those who secure the greatest number of orders.

There are no doubt other points of view from which the effect of small quantities can be considered, but the two which have been referred to are probably sufficient to indicate that such quantities are of practical interest to engineers generally.

DISTORTION OF AN ALUMINIUM CRYSTAL DURING A TENSILE TEST.

THOUGH metals naturally occur in the crystalline state, and not infrequently in well-developed crystals, individual crystals are rarely distinguishable in the metals which we produce in our furnaces. Occasionally crystals several inches in dimensions have been observed in castings of large bulk. In general, however, we have to apply the microscope to see the crystals in steel, which may then be counted in numbers of hundreds and thousands to the linear inch. But it has also been known for at least two decades that suitable combined mechanical and thermal treatment will yield metallic crystals of large dimensions, and those experiments received a stimulus, when it was found, that the tungsten wire filaments, which were to replace the brittle carbon filaments of glow lamps, consisted of strings of short tungsten crystals liable to break at their junctions. By passing the electrically-heated tungsten wire through a short furnace (itself consisting of a spiral of tungsten wire) the Pintsch works then obtained filaments several feet of which consisted of a single crystal.

In 1920, Professor H. C. H. Carpenter and Miss Constance F. Elam succeeded in producing single crystals in sheet aluminium of $\frac{1}{8}$ in. thickness. Continuing these experiments with a purer aluminium of 99·6 per cent., they produced ordinary test bars, $8\frac{3}{4}$ in. long, the parallel portion of which, 4 in. by 1 in. by $\frac{1}{8}$ in., contained only a few crystals, or was all one crystal. Annealed at 550° C. for six hours, that portion would originally contain 150 crystals to the linear inch, or something like 1,687,000 crystals altogether. The bar was then stretched gradually to 1 per cent. and 3 per cent., finally to 30 per cent., by a tensile stress of 4·7 tons per square inch, when the crystals were found to have grown considerably. The stress applied was subsequently found to be too great; when a stress of 2·4 tons per square inch was not exceeded, and the specimen was afterwards reheated very slowly in 48 hours to 72 hours from 450° C. up to 600° C., some bars were converted into single crystals. Of 18 test-pieces treated, as much as possible alike, two finally consisted of one crystal each, six of 2 crystals, five of 3 crystals, three of 4 crystals, and two of 6 crystals.

The conversion of stout test-rods, 0·564 in. and 0·798 in. in diameter, proved more troublesome, and some unexpected effects were observed. Under tensile stress these rods, machined into test-pieces and converted as before, assumed elliptical and lenticular cross-sections and they finally broke, not in cone and cup fashion, but obliquely across a crystal, not along a boundary. Peculiar twists and flow-lines were also noticed, and the single crystals showed remarkable malleability; their ultimate strength was rather smaller than that of the original material, viz., 2·8 tons to 4 tons, against 4·5 tons or 4·7 tons per square inch; but the extension was more than doubled by the treatment, viz., from 38 per cent. to 86 per cent. measured on 3 in.; the strength and extension values, however, varied much with the particular treatment. Professor Carpenter presented an account of these remarkable researches to the Royal Society in December 1921, and this publication induced Mr. G. I. Taylor, F.R.S., lecturer in mathematics at Cambridge, to take up the problem, again in conjunction with Miss Elam. The results of his investigation were the subject of the Bakerian lecture, delivered by Mr. Taylor before the Royal Society recently.

The particular object of Mr. Taylor was to determine the nature of the distortion which Professor Carpenter had observed when a crystal of aluminium was simply extended by direct pull, and to ascertain the relation between the crystal axes and the direction of pull. Professor Carpenter had only been able to measure the end effects. Mr. Taylor attempted to watch the development of the phenomena by the aid of X-ray examination, which offered particular difficulties. In ordinary X-ray examination, the observer either studies the reflection at different angles from a well-defined crystal face, which is rotated with the table on which it is mounted, or he sends the beam through a fine pencil or a thin layer of the powdered material, which will always be more or less crystalline. Neither method was applicable in the case of the stout test-bars used, of 1 cm. by 1 cm. by 20 cm., which were cut from the round aluminium rods previously treated by the method indicated. The external shape of the aluminium bar-crystal gives no clue as to the direction in which the crystal should be set for the X-ray study. Dr. A. Müller, also of Cambridge, who took charge of this part of the investigation, found, however, that there would, in the stout bars as in the thin layer of powder, always be some crystal plane within the surface layer of the metal of sufficient predominance to produce a marked reflection at some definite angle. He observed, *e.g.*, that reflection became noticeable when he set his bar at 8 deg. to the beam of rays; the reflection was strong at 9 deg., and vanished at 10 deg. These angles changed slightly as the bar became distorted, the maximum reflection being then found at 8 deg. Other angles of pronounced reflection, indicating the positions of certain crystal planes, were similarly determined. From these measurements, the angles between the crystal axes and the direction of pull were deduced at different stages.

The specimen was marked with parallel scratches and was submitted to successive extensions of 0, 10, 20, 30, 40, 60 and 78 per cent. of the original length, when it finally broke. As the extension proceeded, the square section changed into a rhombus, and other round specimens became more and more elliptical. The method which Mr. Taylor developed for determining the nature of the distortion was to find lines of particles which remained unextended by the strain. The problem is very complex, and without Mr. Taylor's many diagrams, it is hardly possible even to indicate the way in which he arrived at his solution. If the crystal had originally been a sphere and had been distorted into an ellipsoid (represented in cross-section by a circle and an ellipse intersecting one another) then any diameter common to both these bodies would be such an unextended line, and all these lines would lie on a quadric cone, which evidently would have two positions corresponding with the two configurations from which it was derived. The actual case was much more difficult. But by plotting the angles found on a sphere, Mr. Taylor ascertained that for all stages of the extension up to 40 per cent. elongation, the "unextended cone" was of a degenerate form, consisting of two intersecting planes, one of which contained in all cases the same particles, whilst the other contained different particles for different strains. The former plane was apparently undistorted during the whole strain up to that limiting extension value (of 40 per cent.), and the distortion was due to the slipping or shearing over this plane. The slip plane Mr. Taylor found to be identical with the octahedral plane (111) of the aluminium crystal (which is cubic) and the direction of shear to be along one of the three principal lines of atoms in that plane. When the extension of 40 per cent. was exceeded, slipping evidently took place on another octahedral plane as well, a plane, which had come into a position such that its inclination to the axis was the same as that of the slip plane, thus there was slipping simultaneously on both these planes. Strained above the maximum extension of 78 per cent. the specimen broke, the line of fracture being at about 56 deg. to the direction of the pull. That angle corresponded with Mr. Taylor's explanation, and it would thus appear possible to predict the behaviour of a single crystal within other crystals in a strained material.

Mr. Taylor did not draw attention to the flow lines plainly visible on his distorted specimen. Those lines were curved upwards on the one side of the elliptical portion, and curved downward on the other. Such flow lines and the elliptical contraction were observed in 1913 at University College, when Mr. B. B. Baker and Professor A. W. Porter stretched wires of potassium and sodium and of frozen mercury, and their probable connection with the slip planes was at that time pointed out. Since then, the problems of tensile stress, especially also in single crystals, have been attacked by various methods and the results have been interpreted in various ways. Mr. Taylor remarked in concluding that he and his collaborators had only gone half their way so far. But his Bakerian lecture and his method of analysis mark a big stride in advance.

THE LATE SIR JAMES DEWAR, F.R.S.

WITH Sir James Dewar, who died, in his 81st year, of heart failure on Tuesday, March 27, has passed away a link with an age that had to accustom itself to electric light and trains, that knew neither automobiles nor radiotelegraphy and radioactivity, and that still distinguished between permanent and ordinary gases. That the latter distinction has practically disappeared from our text books, and that low-temperature research has penetrated from the laboratory into big works, is largely due to Sir James Dewar.

James Dewar was born in Kincardine-on-Forth on September 20, 1842, and was educated at Dollar Academy and at Edinburgh University. In 1863 he became assistant to the Edinburgh professor of chemistry, Lyon Playfair (afterwards Lord Playfair); he then continued his studies at Geneva under Kekulé (of benzene-ring fame, later at Bonn), returned to Edinburgh, and was in 1873 appointed

Jacksonian professor of Experimental Philosophy at Cambridge, an appointment which he held until his death, though he did not lecture there during the last few years. His chief appointment, that of Fullerian professor of chemistry to the Royal Institution, dates from 1877. Ten years later he became residential professor and superintendent at the Royal Institution, in succession to John Tyndall. His life work was devoted to the Institution. The choice of the Royal Institution had, of course, not fallen upon an untested man. When he was elected a Fellow of the Royal Societies of London and Edinburgh in 1877, he had done signal work in chemistry and spectroscopy.

In 1869 he had studied the chalybeate waters of Melrose; together with the late Sir William Crookes and Dr. Tidy, he reported for many years on the London water to the Metropolitan Board of Works. He investigated substituted ammonias, pyridine and chinoline bases, the oxidation of phenyl, and hydrocarbons; together with Dr. A. Scott he determined the atomic weight of magnesium. Most of his optical and photochemical work was done in conjunction with Professor G. D. Liveing, of Cambridge, who, born 1827, is still able to enjoy life at Cambridge. They studied various spectra, especially those in the ultraviolet, of metals, carbon and cyanogen, devised a collimating eyepiece and modified Soret's fluorescent eyepiece for spectroscopic work, and determined the influence of pressure on spectra. Dewar also estimated the temperature of the sun and of the electric arc, conducted manometric observations in the electric arc and determined the vapour densities of the alkali metals; he also studied the chemical efficiency of sunlight. Many of these varied investigations were resumed later in the course of the low-temperature research. In the invention of cordite Dewar's name is generally associated with that of Sir Frederick Abel; a third name, that of Dr. W. Kellner, who, born in 1837, died last year, should be added.

The production of cold had exercised Francis Bacon already in his "Sylva Sylvarum," and Robert Boyle had discoursed before the Royal Society on "The Experimental History of Cold" in 1682. In his presidential address to the British Association at Belfast in 1902—where Dewar was again Tyndall's successor—Dewar pointed out that the idea of a very low temperature, at which air would lose all its "spring," had first occurred to Amontons in 1701, It was more clearly formulated independently by J. H. Lambert in his "Photometria et Pyrometria" (1760). Amontons had a fair idea of the absolute zero of temperature (— 240 deg. C. he thought), whilst Laplace, Lavoisier and even Dalton later placed it near — 3,000 deg. C. By 1835 carbon dioxide was liquefied and solidified, and theory and experimental methods advanced so rapidly then that one gas after another succumbed. Wróblewski liquefied oxygen in 1883, and the Royal Institution became famous for its liquid air demonstrations. Only hydrogen resisted all coercion because, contrary to all other gases known, it heats (instead of cooling) when expanded through a fine nozzle or porous plug. In 1898, however, Dewar was able to inform the Paris Académie—he had perviously liquefied fluorine in conjunction with Moissan—that he had liquefied and solidified hydrogen. Hydrogen turned out to be a colourless liquid, one-sixth of the density of water, and a snowy froth, not at all metallic; hydrogen boiled at 20·5 deg. absolute. Dewar had also spoken of liquid helium in his first communication; but that success was left to the superior resources of the Leiden Kryoscopic Laboratory and to Professor Kamerlingh Onnes, who with the aid of helium approached absolute zero within 1 deg. C. or less—if the extrapolations be reliable.

Manifold low temperature researches followed—not free from danger; each of Sir James' assistants, Mr. R. N. Lennox and Mr. J. W. Heath, lost one eye. By means of his vacuum jacket, utilised as thermos flask, Dewar was able to stop convection of heat through vessels of glass, silica or metal, and the silvering of the glass further shut out radiated heat and light. He found in cocoanut charcoal an invaluable means of improving high vacua. He proved that the atomic specific heats of the elements were, at low temperature, a function of the atomic weight like the atomic volume. When the war crippled the resources of the Royal Institution, he took up an old hobby of his, soap bubbles, and our readers know, from our reports on the Royal Institution discourses, how scientifically instructive he made that hobby. His work on capillarity, on permeability to heat rays, his ingenious low-temperature thermoscope, are all valuable, and his demonstrations of the beauty of soap bubble effects were fascinating, though he was not easy to follow as a lecturer. The welfare of the Royal Institution was his great ambition and anxiety. A man of wide and varied interests, he took a personal share in arranging even the highly-appreciated historical and musical lectures; sometimes he was perhaps a little autocratic in exercising his function as residential professor, as his predecessors Humphry Davy and Tyndall had been.

Sir James Dewar was knighted in 1904. All his numerous degrees, including the M.Inst.C.E., were honorary, except his Cambridge M.A. His Bakerian lecture of 1901 was on "The Nadir of Temperature"; he held the Rumford and Davy medal of the Royal Society; the Hodgkis gold medal of the Smithsonian Institute and the Lavoisier gold medal. He was president of the Chemical Society from 1887 to 1899. He married, in 1871, Miss Helen R. Banks, of Edinburgh, and was presented with a gold loving-cup by the Duke of Northumberland on behalf of the Royal Institution, on the occasion of his golden wedding in 1921.

NOTES.

THE STUDENTS OF THE INSTITUTION OF CIVIL ENGINEERS.

The interest taken by the Council of the Institution of Civil Engineers in the relaxations as well as in the professional training of the students of the Institution was shown by the presence of Sir Archibald Denny, Colonel Crompton and Sir Cyril Kirkpatrick, as well as of the secretary, Dr. Jeffcott, at the forty-second annual dinner of the students, which was held at the Trocadero on Friday last. Mr. A. G. Macdonald, B.Sc., chairman of the Association of London Students, presided. The president of the Institution, Dr. W. H. Maw, was to have been the guest of the evening, but, as was explained by Sir Archibald Denny, who replied on the president's behalf to the toast of "The Institution," Dr. Maw had been prevented almost at the last minute, by doctor's orders, from being with them on that occasion. He had, however, sent a message to them by Sir Archibald, expressing his great regret at his enforced absence, a regret which the speaker said he was sure was felt by everyone present. The toast of the "Institution and its President" was proposed by Mr. H. H. Mardon, honorary secretary of the Committee of the Association of London Students, who expressed appreciation of the broader constitution which the council had recently granted to the students, and of the room which had been placed at the disposal of the latter in the Institution building. A suggestion that perhaps the room might be more comfortably furnished was taken up by Dr. Jeffcott in his toast to the students. He said that the furniture the council wanted to see in the room was the students themselves, and when the use of the room justified more furniture of a material nature he was sure that the council would provide it. The student class was founded in 1867, and was now rapidly growing. The numbers had increased by 25 per cent. last year, and there were now 380 members in the London Association alone. The latter apparently did not realise the advantages which the council had provided for them, and the special lectures and visits arranged for their benefit were very inadequately patronised. It was very evident from the subsequent speeches of Mr. McDonald (chairman), Mr. Irving Atkinson (vice-chairman), and Mr. C. B. H. Colquhoun (member), of the Committee of the London Students Association, that the committee fully realise the benefits which an active association would confer on the students and are keenly desirous that the students should take a more effective interest in its doings. The success of other societies of young engineers with regard to attendance at meetings and visits to works proves that such associations are capable of conducting their own business most efficiently, and there is no reason why the students of the Institution of Civil Engineers should not meet with at least equal success. They must, however, rely upon themselves to obtain it, and not upon either the prestige of the great Institution with which they are connected or upon the patronage of its council or members.

THE INDUSTRIAL WELFARE SOCIETY.

In these days, when a section of the community is so anxious to revolutionise society and abolish capital and the so-called capitalistic system, it is notable and gratifying that many employers and many workers are striving to improve the system rather than abolish it, and to evolve from it better and happier relations. The factory legislation of the last hundred years has done a great deal to secure the health and safety of the workers, but the more enlightened employers, instead of contenting themselves with a bare compliance with its requirements, have devoted much time and thought and spent large sums on the general welfare of their employees. This has been done in many different ways at different works. Canteens and recreation rooms have provided increased comfort within doors; sports grounds have afforded opportunities for outdoor recreation; superannuation funds have been instituted to encourage thrift; welfare supervisors have interested themselves specially in the young lads and girls, in times both of health and of sickness; and the association and co-operation of the workers and the employers in welfare work generally helps to bring about a better mutual understanding. The immediate effects of welfare work in improving the conditions of life for the workers are fairly obvious, but the prospect of improved relations between employers and employed is no less important in the interests of both, and it is gratifying that the welfare movement proceeds steadily. Some of the larger employers have been able to work out their own schemes without outside assistance, but most have availed themselves of the assistance of the Industrial Welfare Society, which has its headquarters at 51, Palace-street, Westminster, London, and branch offices in Birmingham, Cardiff, Glasgow, Manchester, Newcastle-upon-Tyne and Sheffield. The society was formed about five years ago by a number of leading manufacturers with the object of continuing the welfare work initiated by the Ministry of Munitions during the war. It is so fortunate as to have as its president H.R.H. the Duke of York. That His Royal Highness takes a real interest in the society is evident from his recent letter to the honorary treasurer, in which he says: "In the many visits which I have made to works up and down the country I have been very much impressed by the happiness engendered both among employers and employed by the adoption of the principles for which the Industrial Welfare Society stands. I feel that our country would gain so much not only in efficiency but also in that greater commodity, happiness, by the spread of these principles, and I wish with all my heart for a large increase in the membership of this society." The society constitutes a central information bureau available to all its members who require guidance and assistance in their welfare schemes. It has a useful reference library; its expert officials are always ready to give counsel and advice; and it takes a leading part in the training of suitable men and women to meet the increasing demand for welfare supervisors. Its great vitality has enabled it to hold its own notwithstanding the present depression in trade, and we hope that as trade improves its membership among engineering employers will greatly increase, so that the field of its humane and noble efforts may be considerably enlarged.

AN ULSTER HYDRO-ELECTRIC SCHEME.

It is estimated that the Ulster linen industry at present utilises 125,000 h.p., of which 55,000 h.p. is used in Belfast, and the remaining 70,000 h.p. by the mills scattered throughout the six counties outside Belfast. More than 1 h.p. per operative is absorbed in the industry, and the whole question of a cheap power supply is of great importance. The cost of coal is high at the various linen mill centres and it has practically all to be imported. The cost of Irish coal is equally high, and in any case the average output of Irish collieries for the past

twelve years was only 86,000 tons, as compared with an average import of 4,500,000 tons into the country. This state of affairs lends great interest to a projected hydroelectrical scheme for the development of the water power of the River Bann which rises in Lough Neagh and flows northward to Coleraine for the few miles beyond which the river is tidal. The Bann Syndicate, Limited, has been formed for the carrying out of the scheme, and a private Bill is to be introduced in the Northern Parliament. The consulting engineers for the work are Messrs. J. F. Crowley and Partners, who are acting in association with Messrs. Meik and Buchanan. The present proposal covers the development of the whole of the power of the river at one station with a head of 27 ft., utilising 75 per cent. of the head available between Lough Neagh and high water-level at Coleraine. The scheme is of considerable interest to the many riparian owners around Lough Neagh as the proposals cover the regulation of the waters of this lake, which will have a favourable influence on the country surrounding it. At present much loss is caused to the farming community by flooding, and the removal of this source of trouble will be to many landowners as attractive a feature of the scheme as the cheap power possibilities which it promises. The total capital cost of the ultimate development, is expected to be something less than 1¼ million pounds, and it is expected that even in the earlier stages it will be possible to sell power in the proposed area of supply at a rate considerably below that which now rules for power consumers in Belfast, although coal prices in this area are now higher than in Belfast. The whole district concerned is at present but poorly supplied with electricity, and if the scheme can be carried to a successful completion it should be of great value to the country.

BRITANNIA METAL.

Although utilised chiefly in the manufacture of articles for domestic use, and consequently of little or no importance to the engineer, the physical properties of Britannia metal are not without interest to the metallurgist. The peculiar characteristics of this alloy formed the subject of a lecture delivered by Captain F. Orme before the Sheffield Section of the Institute of Metals on the 23rd inst. Dealing with composition the lecturer gave the percentages of tin, antimony, and copper as being 90 to 94, 5 to 7, and 1 to 3 respectively. The presence of copper was essential to secure hardness, but for high-class metal such as that used for spinning purposes this should not exceed 1·5 per cent. The well-known property of antimony, viz., expansion on cooling, gave good sharp castings. The general procedure followed in Britannia metal melting shops was to melt the antimony and copper separately, pour the former into the latter and then add this melt to the previously melted tin. The molten alloy, contained in a cast-iron pot, was then stirred or "fluxed," as it was termed. This, in reality a refining process, was done by means of sal ammoniac or resinous wood such as pitch pine. The steam and permanent gases evolved caused violent ebulition to take place and exposed the melt to the atmosphere, impurities such as lead and iron were thus oxidised and passed into the slag. This process also produced a good homogeneous alloy. The casting temperature was usually determined by some rough shop test which, in the lecturer's opinion, should be replaced by pyrometric control. The ingot moulds employed, usually of brass or gun-metal, were always warmed before use and often coated with lampblack. The "blisters" sometimes obtained on rolling were no doubt caused by carelessness in the melting shop; the moulds should always be carefully cleaned before each cast and the ingots produced scratch-brushed before rolling. Cracking during spinning was another difficulty encountered by manufacturers. Investigating this problem, the lecturer found that, although the original ingredients of the alloy were carefully and accurately weighed out, the subsequent operations were often so protracted as to cause loss by oxidation of the tin and the antimony and consequent gain in the proportion of copper. In one case, which had come under his notice, the original copper added was equivalent to 1·5 per cent., but the ingots produced showed that this percentage had risen to 2·34. Again a small proportion of iron, found in the finished metal, had been introduced by long standing of the molten tin in the cast-iron pot. Both these factors had highly deleterious effects. Small increases of copper greatly increased the hardness of the alloy and iron invariably had an embrittling effect. With regard to mechanical properties, the lecturer stated that rolling, usually done in the cold, progressively softened the material. The effect of quenching was most interesting; when heated to 170 deg. C. and rapidly cooled the metal was considerably hardened and gave out a metallic ring when tapped quite unlike the dull, lead-like sound of untreated metal. This resonance compared favourably with that of nickel-silver, and when it was considered that 95 per cent. of the Britannia metal produced was used in the manufacture of silver-plated articles, this property combined with increased resistance to shock greatly enhanced the value of the material.

LITERATURE.

The Work of the Royal Engineers in the European War, 1914–19. Military Mining. Published by the Secretary, Institution of Royal Engineers, Chatham. W. and J. MacKay and Co., Limited, Chatham, 1922.

This recent addition to the series of publications detailing the work of the Royal Engineers in the Great War, describes the part played by that distinguished corps in the work of military mining, and adds fresh testimony to the tale of ingenuity and resource, gallantry and devotion displayed, for which we had been prepared by the earlier chronicles. Modern ordnance had proved its superiority over the defence offered by the strongest fortresses so markedly that the tactics of mining evolved from experience gained in the attack and defence of forts had fallen into disuse and obsolescence. But it was soon found that trench warfare, where often less than 50 yards separated the hostile fronts, offered opportunities for the use of the neglected weapon of mining in connection with explosives.

The Germans were the first to exploit the method and before the end of 1914 definite instances of mines exploded under our trenches were reported. Then followed hurried enlisting of underground workers and professional "clay kickers," as evidenced by the fact that only one day after the War Office had sanctioned the formation of eight companies, the first party of miners arrived in France to form the nucleus of a force, which in little more than a year's time was to number 25,000 men. It is said that some of the men in this first instalment had been at work on the sewers of Liverpool only five days previously. Though late in starting on this dangerous game of mining and countermining, it is comforting to read that by the autumn of 1917, the British miner had so completely established his superiority "that the enemy was reduced underground to a state of absolute passivity on the entire front." Trained science contributed not a little to this success. Under a distinguished professor of geology, a body of geologists were continuously at work, whose services were invaluable in coping with inconveniences arising from underground water. The variations in water level gave infinite trouble, the difference in level between summer and winter amounting to as much as 30 ft. In the early days, deep level galleries were submerged and temporarily lost by both sides, but when geology had become a part of mining organisation, such instances were rare, and a rise of water level of 18 ft in 15 days was foreseen and controlled.

The plans of attack and defence developed during the course of the struggle are fully detailed, the reason for the gradual increase in depth of the mines in order to construct galleries below those of the enemy is explained, the precautions taken to prevent information leaking to the German side, and the schemes devised to detect the hostile position and purpose, all make very interesting reading, but must be passed over. The progressive work may be said to have culminated in the successful explosion on the Messines front on June 7, 1917, when a million pounds of high explosive were simultaneously fired, shaking the earth for miles around, sending up a sheet of gorgeous flame which announced the success of the undertaking, and gave the signal for every gun within range to open fire. Those privileged to view the spectacle could give but inadequate descriptions, for the scene was too bewildering and the variety of incidents distracted attention. Though success was complete, we learn now how near was failure, and the character of the circumstances which threatened disaster. The preparations could be completed only a few hours before the appointed time, work being carried on while the enemy could be heard at work in a neighbouring gallery, in which he was uninterrupted, as it was believed that his work would pass just clear of our own operations. From an engineering point of view, the enterprise was an undoubted success, but its strategical value has been questioned, both at the time and since. If the testimony of a defeated general may be accepted, the question is settled, for Ludendorff has admitted "that the moral effect of the explosion was simply staggering: at several points our troops fell back before the onslaught of the enemy infantry."

A second section of the report refers to mine rescue work and to the casualties from gas poisoning, defective ventilation, falling roofs and other causes, which gave constant employment to a specially trained staff. Schools were started for instruction in the use of apparatus, rendering first aid, and other forms of rescue work. Various forms of apparatus were tried, whose value and deficiencies are pointed out and some improvements were effected to meet special requirements. It will be sufficient to say here that the "Proto" apparatus and those designed on similar lines established their superiority. The approved "mine stretcher" was an outcome of the Mine Rescue Schools, and the gas testing set was designed at the Central Laboratory, but in detecting the presence of CO canaries and mice proved useful. It is pathetic to note that the birds became such pets with the men who, therefore, would not always expose them in dangerous places, preferring to accept the risk themselves. Some very useful details on the use of oxygen and artificial respiration are given that will be of service in civil life. An appendix supplies some information on German method of treatment, derived from captured systems, and it is very certain that the Allies had nothing to learn from "German thoroughness and efficiency." Except at Arras and on the Somme "there appeared to be a total absence of any regular mine rescue system along the whole German front. . . . the Germans had nothing at all approaching the 'Proto' in comfort, safety and efficiency, nor any method of giving oxygen equal to the 'Novita.'"

The third and last section is purely technical, describing the general procedure followed in laying out a mine system according to the objects to be attained. Here the military student can trace the growth of mining tactics, as brought home to our officers and men by the severest experience. The numerous diagrams enable the untrained reader to grasp the process and to appreciate the reasons for the practice adopted. The disposal of the spoil so as to escape the observation of a vigilant enemy is not a simple process, and many devices had to be improvised, but to combine convenience and safety with efficiency and speed, taxed ingenuity and responsibility to the utmost. In addition to carrying out this service within our own lines, it was necessary to maintain the strictest watchfulness over the enemy's subterannean work. Two instruments, the outcome of necessity, the geophone and seismomicrophone, are described and their use illustrated: the former was of value in determining the distance of sounds, the latter for listening in gas permeated galleries. The system of "central listening" was brought to such a state of perfection, and the interpretation of the sounds so just, that after the capture of the various hostile systems it was found that the actual position of their galleries corresponded accurately with the positions on the plans constructed from the listening records. Here we must leave the wonderful tale of mine and countermine, of heroism and sublety, but in justice to all ranks who took part in the scheme, we would fain quote the terse testimony of the Engineer-in-Chief to the C.G.S., dated January, 1919:—"The tunnelling companies have acquired a great reputation in the War for efficiency, stout-heartedness and general usefulness, apart from their proper rôle in which they have always had the upper hand over the enemy."

The Philosophy of Management. By OLIVER SHELDON, B.A. (Oxon.). With a foreword by B. Seebohm Rowntree. London: Sir Isaac Pitman. 1923. [Price 10*s.* 6*d.* net.]

THIS is a very valuable book: practical in its details wide in its outlook, well defined in its aim, and thorough in its treatment, it offers a comprehensive view of one of the many problems which tend to hinder the healthy recovery of industry, and furnishes some thoughtful suggestions that the opponents and advocates of innovations may consider with advantage. By limiting attention to the one subject of general industrial management and efficiency of organization, whether in direction, in the staff, or in the workshop, the author is able to discuss profitably a scheme of restricted extent, that avoids many of the contentious topics that the more daring and speculative of the claimants for notoriety urge on the attention of a long suffering public. He may hope for an attentive hearing, for he asks for no industrial upheaval, and proposes no

untried schemes that may lead to disaster, but are rendered attractive to a certain form of mind by the magnitude of the forces involved. Moreover, the criticisms are not intemperate nor revolutionary. Mr. Sheldon is not one who believes, or affects to believe, that whatever served in the past must necessarily stand condemned as futile or inadequate, and that consequently the methods of the last generation bequeath no useful lesson to the next. Experience and tradition are not lightly thrust aside to give room to novelty and extravagance. It is admitted that theoretical plans, unsubmitted to practice, may need recasting and correction. The author is prepared to go slowly, and this moderation gives him the right to enquire whether the administration and direction exhibited in industrial schemes have been sufficiently elastic, and show a ready adaptation to the varying conditions of industry, both personal and mechanical. Labour has developed schemes, formed combinations and acquired a strategical position from which fresh advances will proceed with accelerated pace. The results of science have been utilised in unforeseen methods and made to yield results as valuable as unexpected, but it is questioned here, whether management, using the word in its widest sense, has risen to its full capacity, and availed itself of that broader and more intelligent outlook which would enable it to draw the full advantages from the new elements and altered environment with which it is confronted. Between management and labour the connection is intimate and co-extensive, and organisation must accommodate itself to the material with which it has to work. It is as inherent in the composition of industry as labour itself, and whatever scheme of conduct and government the reformers of to-morrow may insist on, it will have to fulfil the same functions as under the present regime, and accept the same share of responsibility.

In two preliminary chapters, Mr. Sheldon offers a panoramic survey of the historical and social background of industry, exhibiting the factors personal and material that enter into the problem. He explains precisely what he means by management, and dwells on the necessity of developing its capacity and its policy on a scientific basis. Organised labour is presented in a kindly and sympathetic light, and the responsibilities of management both to the community and to the workers it seeks to control is the keynote to much that follows. While we heartily appreciate his urgent appeal to the human side of the grave labour problem, we are not prepared to accept without reservation the views on which the author insists. We doubt if he is justified in presenting the labour problem and the relations existing between employer and employee as being regarded by labour entirely as an ethical question. The attitude of labour towards the broad theory of service to the community, seems to contradict that view. We could wish that the point was as evident as the author thinks it, for such a view would remove much of the selfishness and strife with which the problem is encumbered. The more lofty view may represent the opinions of the thoughtful idealist, but the hope of accomplishing the "dictatorship of the proletariat" appeals more persuasively to the rank and file. A spirit of vindictiveness directed against capitalism is abroad and the tactics adopted, in opposition to all sound economic principles, as a means of coercion and punishment point to conditions of unreasoning hostility incompatible with philosophic vision.

To discuss what should be the minimum wages payable in shillings and pence operates almost as an anticlimax after indulging in the elevated views of service and of scientific management, but since the amount must be settled on purely economic grounds, determined by what the industry will bear, it may be questioned whether the author has given sufficient weight to two important factors that may conflict with ideal ethical considerations. The one is foreign competition. We must sell our manufactures since our population is not self-supporting, and the other is, that with greater purchasing power may come an increase in the price of commodities, so that we should find we had virtually embarked on a vicious circle whose pursuit brought us no nearer a desirable goal. Moreover, the loyal attachment of the workers to an ancient shibboleth, whose observance, if pursued to a logical end, would accomplish the destruction of the home markets, does not make advance on economic lines easier, but these are problems in industrial life into which we have no intention of entering. Neither can we describe the many applications to factory practice, to the machinery by which better relations between director and operative can be secured, or to the linking up of management and execution. With much that is said we are in very hearty agreement, and we imagine that all will approve of the spirit and manner in which the suggestions are submitted and the arguments presented.

Restriction of space will permit reference to only one well worked out scheme, that special training is indispensable for those to whom is entrusted the execution of the duties of management. Put in that crude way it reads like an axiom, but there have never been wanting those who think that intuition is better than instruction, and that scientific method is much overrated. Success may be sometimes secured in spite of method, and good fortune can be mistaken for ability. But as management becomes more complex and its responsibilities increase, the practice of the profession becomes more difficult. Whether an adequate supply of teachers exists is a more important point, and of this we should entertain grave doubts. But such books as this indicate a great awakening, and in the near future we may expect the industrial leaders to insist on the introduction of the results of strict scientific research into the methods of manufacture and of commerce, placing in the hands of those who are capable of using them, weapons wherewith to meet the active competition of nations more favourably situated or better supplied with raw material.

Civil Engineering Geology. By CYRIL S. FOX, B.Sc., M.I.M.E., F.G.S., Geological Survey of India. London: Crosby, Lockwood and Son. 1923. [Price 18*s.* net.]

THE author of this treatise has evidently had wide experience on construction works in India, where his expert knowledge has been sought to assist in determining the character of geological formations, and the influences they exert on the conduct of engineering operations. His experience showed him the need of an elementary guide to practical geology, and a paper entitled "Some Engineering Aspects of Geology" was prepared for the Institution of Civil Engineers (India) which has been made the foundation of this work. The object of this treatise, therefore, appears to be to indicate when, and under what circumstances, it would be desirable for an engineer to consult the geologist, the nature of the information the enquirer might expect to obtain, and the most effective use that could be made of it. From that point of view the book is not without value, and we do not imagine that the author proposes to supply the instruction necessary to enable the engineer to derive for himself trustworthy direction in complex situations. Mr. Fox points out rightly enough, the dangers and losses that may easily follow the neglect of precautions, but this is not the same thing as the power to select the most appropriate or economic course from a number of alternatives. The data for the solution of any problem are generally collected by the engineer, from borings, wells, trial pits, &c., but to determine from the character of the rocks encountered, those most suitable for a particular undertaking, so as to secure the utmost possible stability on a hill side, or those best adapted for road or building stone, is the work of the geologist and one not lightly to be undertaken. Larger problems as the selection of the location of dam sites, or the degree of water tightness to be expected in a reservoir basin, are of such fundamental importance that those who enter on such operations would exhaust every source of information and omit nothing that could add to security.

The book is divided into three sections, implying that a great variety of subjects is examined. The first is devoted to water supply and irrigation and occupies 26 pages. The second, concerned mainly with field operations, as tunnelling and mining, is dismissed in some 40 pages, and the remainder of the work is given up to the subject of building materials. Under these conditions one does not look for exhaustive treatment, and even clearness may be sacrificed to brevity. Each section has many subdivisions. In the first section the reader is taken through the cycle of precipitation, to the behaviour of rivers and canals, and finally led to trace the recovery of water from wells under artesian conditions. On the way he may learn something of irrigation, the dangers attending an excess supply of water and the formation of alkali. It would have been very interesting if the author had compared his experience and knowledge of results acquired in India, with the published accounts of the progress of irrigation in the United States and elsewhere, but allusion to results obtained outside India are scant and very cautiously made.

The subjects discussed in the second section embrace the construction of dams and revetments so far as geological conditions may modify the structure or suggest special precautions. Perhaps the most beneficial services geology can render to engineering may be found in the department of tunnelling and in those of mining and quarrying, but we have no statistics to show how successful the science has been in its warnings of the presence of unsuspected dangers, as the outbursts of water, hot springs, &c. Accuracy in the location of hidden trouble must be very difficult in the narrow line occupied by a tunnel, and it is doubtful, if an engineer would feel himself justified in modifying his plans on the unsupported deductions of a geologist. The author does not speak with the decision that gives confidence. If, he says, a detailed geological examination has been made, "it is generally possible, unless the rocks have been subjected to exceedingly complex folding, to predict the conditions likely to be met with in driving a given tunnel." In mining and quarrying, the work must be carried on where the ore body exists and choice of position being out of the question the teachings of geology are of little avail, methods being devised to meet the conditions on the spot. The assistance that geology may render to the prospector is not under review.

The third section on the occurrence and selection of building materials is prefaced by some general remarks and definitions that might, with advantage, have been given earlier in the book. The distinguishing feature, however, is the number and excellence of the photo-micrographs showing the structure of typical rocks. How far such methods of discrimination are trustworthy and instructive as a guide to selection, when ordinary testing and superficial examination give uncertain indications, is not perhaps definitely known, for many years of experimental use are required to detect a slow deterioration, whether in road material or building stone. But apart from these special reproductions, the beauty of the general illustrations should be fully acknowledged. Some of the originals have been lent by the Geological Survey of India; they are admirably characteristic and add much to the value of the treatise.

BOOKS RECEIVED.

Etudes Elémentaires de Météorologie Pratique. By ALBERT BALDIT. Second edition. Paris: Gauthier-Villars et Cie. [Price 24 francs.]

American Machinist Year Book. Simplified Tables and Formulas for Designing, and Practical Points in Cutting All Commercial Types of Gears. By CHARLES H. LOGUE. Revised by REGINALD TRAUTSCHOLD, M.E. Third Edition. London: McGraw-Hill Publishing Company, Limited. [Price 15*s.* net.]

University of Illinois. Engineering Experiment Station, Circular No. 10. *The Grading of Earth Roads.* By WILBUR M. WILSON. Urbana, Illinois: University of Illinois. [Price 15 cents.]

Jigs and Fixtures. By FRED H. COLVIN, M.Am. S.M.E., and LUCIEN L. HAAS, M.Am.S.M.E. Second Edition. Revised and enlarged. London: McGraw-Hill Publishing Company, Limited. [Price 12*s.* 6*d.* net.].

Machinery Foundations and Erections. TURRELL CROFT, Editor. First Edition. London: McGraw-Hill Publishing Company, Limited. [Price 25*s.* net.]

Practical Mechanics and Strength of Materials. By CHAS. WILBER LEIGH, B.S. First Edition. London: McGraw-Hill Publishing Company, Limited. [Price 11*s.* 3*d.* net.]

State Power-Plants in Sweden, 1921. *General Description. Published by the Royal Board of Waterfalls.* Upsala: Almqvist and Wiksells Boktryckeri A-B.

Kolben-und Turbo-Kompressoren. Theorie und Konstruktion. By P. OSTERTAG. Third Edition. Berlin: Julius Springer. [Price 16*s.* 8*d.*]

La Théorie de L'Allotropie. By DR. SMITS. Paris: Gauthier-Villars et Cie. [Price 55 fran s.]

Farm Implements and Machinery. By J. R. BOND, M.Sc., M.B.E. London: Benn Brothers, Limited. [Price 35*s.* net.]

Die Methode der Festpunkte. Zur Berechnung der Statisch unbestimmten Konstruktionen. By DR. ING. ERNST SUTER. Berlin: Julius Springer. [Price 18*s.* 4*d.*]

Lockwood's Builders', Architects', Contractors' and Engineers' Price Book, 1923. Edited by J. P. ALLEN. London: Crosby Lockwood and Son. [Price 7*s.* 6*d.* net.]

Nickel. The Mining, Refining and Applications of Nickel. By F. B. HOWARD WHITE, B.A. London: Sir Isaac Pitman and Sons, Limited. [Price 3*s.* net.]

Cam Design and Manufacture. By F. B. JACOBS. London: Constable and Co., Limited. [Price 13*s.* net.]

Statik. By WALTHER KAUFMANN. Berlin: Julius Springer. [Price 7*s.* 6*d.*]

Janes' Fighting Ships, 1922. Edited by OSCAR PARKES, O.B.E., M.B., London: Sampson Low, Marston and Co., Limited. [Price 2*l.* 2*s.* net.]

Annual Report of the Commissioner of Lighthouses to the Secretary of Commerce for the Fiscal Year ended June 30, 1922. Washington: Government Printing Office.

United States Bureau of Mines. Bulletin No. 167. *Coal-Dust Explosion Tests in the Experimental Mine,* 1913 *to* 1918, inclusive. By GEORGE S. RICE and Others. Washington: Government Printing Office. [Price 1 dol.]

United States Geological Survey. Bulletin No. 728. *The Occurrence and Uses of Peat in the United States.* By E. K. SOPER and C. C. OSBON. [Price 50 cents.] No. 731. *Bibliography of North American Geology for* 1919–1920. By JOHN M. NICKLES. No. 735–F. *General Features of the Brown Hematite Ores of Western North Carolina.* By W. S. BAYLEY. No. 736–D. *The Osage Oil Field, Weston County, Wyoming.* By A. J. COLLIER. Professional Paper, No. 130. *The Laramie Flora of the Denver Basin. With a Review of the Laramie Problem.* By F. H. KNOWLTON. [Price 40 cents.] Washington: Government Printing Office.

An Introduction to the Principles of Mechanics. By J. F. S. Ross, M.C., B.Sc. London: Jonathan Cape. [Price 12*s.* 6*d.* net.]

Research Department, Woolwich. R. D. Report No. 55. *The Properties of Some Nickel-Chromium Steels.* London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 7*s.* 7½*d.* post free.]

"TURNING PISTON RINGS."

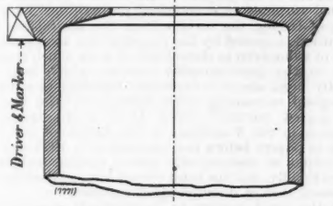
TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of February 9, last, on page 165, Fig. 60, there is shown a method of turning piston rings on a capstan lathe. This modification of a capstan lathe seems to be a poor policy to assure results, the tool mounted on a slide arranged to oscillate by means of a *cam* is all wrong, this particular slide should be operated by a *crank* or *eccentric* driven by a one to one pair of gears when eccentric piston rings are produced. The production of a simple piston ring is perhaps the most important and least understood detail necessary in the manufacture of an engine, and it is a common failure to recognise the important factors that enter into every phase of its value as a spring ring that must fit a bore after being sprung into a piston groove. Freak designs are offered as a solution for all the failures of others. The writer had the problem of producing satisfactory rings and perhaps his solution will tend to point out the causes of failure.

The first essential is design. I will assume a simple ring with a single diagonal slot and quantity production to be the rule. A gate of metal patterns, four in a flask, and machine moulded to get uniform casting is desirable, the patterns should have a uniform and minimum amount of finish. A suitable flange for chucking the castings and machining them is desirable. A suitable flange would be $\frac{1}{2}$ in. thick, somewhat larger than the outside diameter of the ring pot, the edge of the flange being 30 deg. angle to fit the undercut chuck jaws; the flange should also have a projection on its edge to act as a driver against the side of a marked chuck jaw, which also indicates and registers the thick side of the ring casting. To better resist the crushing action of the chuck jaws I prefer to provide an internal flange somewhat thinner than the other flange, and both filleted to avoid a rough corner in moulding and casting. See sketch of flange design, below.

The metal a ring is cast with should be hard to resist wear and be a spring ring when finished; uniformity is also important. The casting should be cast at the

SECTION OF PISTON RING FLANGE.



proper period and with metal tapped for that purpose, never with dregs from some other "important casting," other castings are less important. Rings castings should be "*annealed in the mould*" until cold, any attempt to expose them too soon is to invite trouble later, due to local cooling, which causes hard sections. The first machine operation can be very satisfactorily done on a Gridley semi-automatic, fitted with a universal jaw chuck to fit the 30-deg. flange, a standard cylinder boring head or a rigid holder to size the inside of the ring is reliable. The back slide is used to turn the outside either concentric or eccentric in ordinary practice, while the boring head leads and cuts about $\frac{1}{4}$ in. ahead of the outside tool. The thin internal flange avoids fouling of the boring head.

The rings are parted off by the usual gang tool block that is mounted on the front of machine, while each parting tool leads the next; the corner of the parting tools should lead sufficient to prevent a ridge on the rings, by the angled corner breaking through first where the ring is severed from the pot.

At this point a simple test should be applied to determine the value as a spring, since it must be sprung into a piston groove without distortion or taking a permanent set. Slit a single ring with a hack saw, and note the opening; force the ring over a cone, up to a stop flange on a diameter equal to that of the piston plus, say, $\frac{1}{16}$ in. on a 4 in. diameter ring; remove the ring and note the width of the slot; if it is wider due to the ordeal, discard the lot as being too springless; if they break with this test due to poor design, &c., then consider they must spring into a piston groove. It is not usual that hard rings get that far, for the tools speeds and feeds automatically inspect *chilled* rings.

The next operation is to face and finish the sides of the rings by grinding; a Heald ring grinder is quite reliable for that. Then follows the formation of the slot, and when diagonal I find two slitting saws spaced with a collar faster than a cutter, and the latter more liable to break rings even in a jig that is well designed.

The last operation—that of grinding the diameter to fit the cylinder bore—is where the trouble develops; the result is either rings or "scrap." There is only one way to avoid trouble, and produce rings that fit, and that is to grind them on an arbour with the ends of the rings open $\frac{1}{16}$ in. and to a diameter sufficient to regulate the amount of slot opening in a cylinder bore. To regulate the slot opening on an arbour with a given amount removed to get the desired spring, it follows that the diameter of the outside of the ring pot with the first operation must be held within limits, so that the circumference does not vary with a given slot removed; with this it follows that rings ground $\frac{1}{16}$ open on an arbour can be any desired opening in a cylinder by regulating the diameter that the rings are ground to, while distortion in a sleeve is avoided. Any attempt to finish rings with the ends close on an arbour and to the cylinder diameter will end in failure. The above policy was decided after my analysis proved I had solved the ring fit problem. It is used commercially to-day.

I am yours truly,

JAMES MCINTOSH.

2,964, Corydon-road, Cleveland Heights, O., U.S.A.,
March 2, 1923.

"THE EFFECT OF REPETITION STRESSES ON MATERIALS."

TO THE EDITOR OF ENGINEERING.

SIR,—It has been pointed out to me by Mr. Gough that readers of my paper, published in ENGINEERING, February 16, might possibly think that he had borrowed from us the optical method of determining fatigue range. No such suggestion was ever intended, as will be seen, I think, by reading what was said in the paper.

Mr. Gough's first description of the method used by him showed a mirror fixed to a bearing through which the specimen was loaded, but Mr. Gough informs me that as early as 1919 he was using a method similar to that described in my paper. Our first sketches were made early in 1919, and it would appear therefore that quite independently we were developing a similar method

Yours truly,

F. C. LEA.

The University, Edgbaston, Birmingham.
March 26, 1923.

"ROTATING DISCS OF CONICAL PROFILE."

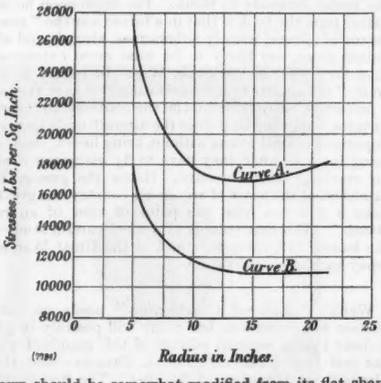
TO THE EDITOR OF ENGINEERING.

SIR,—I was exceedingly interested in your articles, the last one of which appeared in January 26 last. The problem is one that has interested me for many years, but the solution of which has always baffled me. I wish to congratulate the author on his ingenious solution which I consider of immense value to engineers, not only in connection with rotating discs but with other stress problems. I shall be much obliged if you put me in touch with the author in order that he may confirm (or otherwise) a point in his article which appears to me an error.

Using the figures and constants calculated by the author it appears that the figures inserted for the tangential stress at the outside (σ_{t_2}) and inside (σ_{t_1}) should be as follows:—

$$\sigma_{t_2} = 15420 + 2{\cdot}608 \times 487{\cdot}7 + 3{\cdot}407 \times 437{\cdot}9$$
$$= 15420 + 1271{\cdot}9 + 1491{\cdot}9 = 18183{\cdot}8$$
$$\sigma_{t_1} = 11230 + 1{\cdot}568 \times 487{\cdot}7 + 35 \times 437{\cdot}9$$
$$= 11230 + 764{\cdot}7 + 15326{\cdot}5 = 27321{\cdot}2.$$

The author's figures named and plotted in the curve are 16,910 and 26,560 respectively. It would appear that these figures have been obtained by altogether omitting the second terms. As I am making considerable use of the author's solution, and wish to make sure I have not walked into a pitfall, I shall be much obliged to hear whether my figures are correct. If this be so, the curve



shown should be somewhat modified from its flat shape in the neighbourhood of the periphery, as the tangential stress is actually larger at the outside than further in. I calculated curve A using different points to the author for the purpose of making comparisons with other forms of discs; this curve shows the increased stress at the periphery, also an absence of the somewhat sharp knee in the author's curve. Curve B was calculated on the basis of the external loading being 0 instead of 8,850 lb. per square inch. In this case the curve recovers a more normal shape and does have the flat character mentioned by the author in his concluding paragraph.

I shall esteem it a favour if the author explains how his table may be used in the case of a complete disc with a pinhole at the centre or solid there. No external loading at outside or inside. In either case it appears to me that the constant A = 0. At first sight it appeared to me that B also = 0 (except in the case of the pin-holed disc when $\propto$ B = 0·1354 T at inside only). As this would mean that g_o (by itself) would represent the tangential stresses (except at the inside of the pin-holed disc where the stress would become double) and the stresses would increase continuously from the outside to the in, it is apparent this value for B is not correct. I should be much obliged to know the correct value for either case as I do not follow how this can be obtained from Table No. II.

Yours faithfully,

L. W. SCHUSTER.

British Engine Boiler and Electrical Insurance Co., Ltd., 24, Fennel Street, Manchester.
March 17, 1923.

[Mr. Schuster is quite right, there is an arithmetical error in the illustrative example, and we are much obliged to him for the correction. As regards the queries with which he concludes his paper, the solution for the case in which the disc is solid is found by putting the coefficient of $p_2 = 0$, and selecting that for p_1 so as to make the radial stress zero at the outer circumference. We cannot, however, give offhand the solution for the case in which there is an infinitely small hole at the centre of the disc. This problem probably involves the estimation of certain limiting values by the methods of the calculus.—ED. E.]

THE OPTICAL SOCIETY.

AT a meeting of the Optical Society held at the Imperial College, on Thursday, March 22, 1923, Instructor-Commander T. Y. Baker, B.A., R.N., in the chair, a lecture on "*Surveying and Navigational Instruments from a Historical Standpoint*," was given by L. C. Martin, D.Sc., F.R.A.S.

The lecturer referred to the development of the geographical sciences in very ancient times and the accurate knowledge of the Mediterranean basin obtained by Ptolemy before 150 A.D. One of the best known of the early instruments was the astrolabe, and the development of this instrument by the Arabs and others down to the sixteenth century was traced by pictures and by specimens from the Science Museum, South Kensington. Specialised forms suitable for navigation were described. Various forms of astronomical, nautical and surveying quadrants were then explained, as well as the cross staff and the back staff, and the methods of use of these latter. Later quadrants illustrated the improvement in accuracy of the graduations of the circle.

In the seventeenth century a somewhat simplified form of astrolabe, capable of being suspended or mounted horizontally on a stand, was found employed as a theodolite. This was subsequent to the description of Digges's *theodolitus*, in which independent horizontal and vertical axes were employed. The use of the telescopic sight was not applied to surveying instruments till the beginning of the eighteenth century. Specimens showing the transition were exhibited. The history of the level, from the "open sight and gravity controlled" forms, to the telescopic levels of Picard, and the bubbles of Thévenot, was also discussed. Several specimens were exhibited to show the development of the sextant and the various constructions employed to secure rigidity. Borda's repeating circle was also described.

Improvements by various artists in the methods of graduation of circles and the development of dividing engines, from Hindley to Ramsden and Troughton, were matters of the greatest moment in the development of modern instruments. Various forms of late eighteenth century theodolites were exhibited, and the work and the influence of Ramsden was illustrated. Later developments were shown in the instruments by Troughton and by Cary, which brought the level of construction (from the purely scientific standpoint) almost up to that of our own time. Various developments of the nineteenth century, including the work of Porro on tacheometry were mentioned. Later work has produced instruments far better suited to conditions of use in the field. The lecture was illustrated by many lantern slides (including some of exhibits from the Museo di Fisica Florence) and also by exhibits from the Science Museum, through the courtesy of the director, and Mr. T. H. Court, by whom many of the instruments are loaned to the museum.

POWDERED COAL COMBUSTION TESTS.—Tests of a large boiler fired with powdered coal, were conducted recently at a plant of the Milwaukee Electric Railway and Light Company, by the United States Bureau of Mines and the Combustion Engineering Corporation. The object of the tests was to determine the thermal efficiency, ease of operation, and other particulars of a boiler equipped with specially-designed furnace and burners for burning powdered coal. The boiler tested has 13,380 sq. ft. of heating surface, and is one of eight boilers equipped with the Lopulco powdered coal system supplying steam to two 20,000-kw. steam turbines in the largest power-house burning powdered coal. Twenty-six tests were run at rates of heat transference varying from 4,000 B.t.u. to 8,000 B.t.u. per sq. ft. of boiler heating surface, and the mean thermal efficiency attained was about 84 per cent., based on the gross calorific value of the fuel as fired. The efficiency varied little with the rate of steaming, and its high value is accounted for by the small loss from incomplete combustion and the small amount of excess air which varied from 5 per cent. to 36 per cent. The coal burned had a gross calorific value of about 11,500 B.t.u. to 12,800 B.t.u. per lb., contained 2 per cent. to 5 per cent. moisture, 33 per cent. to 36 per cent. volatile matter, and 9 per cent. to 13 per cent. ash, and was so ground that 89 per cent. to 95 per cent. would pass through a 100-mesh sieve. The ash had a softening point of 2,150 deg. to 2,450 deg. F., but did not fuse together at the bottom of the furnace because it was partly protected from the flame radiation by means of a series of water tubes connected to the boiler which were placed between the furnace bottom and the flame.

NOTES ON NEW BOOKS.

The United States are becoming resigned to the depletion of their wealth of natural oil. In February, 1922, the Geological Survey of the Union estimated that there remained 9,150,000,000 barrels of petroleum underground, recoverable by current methods of production; the country was then producing oil at the rate of 500,000,000 barrels a year, and at that rate the petroleum would hold out twenty years. More oil may, of course, be recoverable; but the consumption is increasing at an alarming rate. Thus other sources of oil, oil-shale deposits in the first instance, are receiving more serious attention, and the State of Colorado in particular considers that its own vast oil-shale deposits will ultimately place Colorado in the front rank of the oil-producing States of the Union. Bulletin 210 of the Bureau of Mines, on "*Oil-Shale, an Historical, Technical and Economic Study*," by Martin J. Gavin, gives a summary of the State of Colorado co-operative oil-shale investigations; the volume of 201 pages has been printed by that State in recognition of the potential importance of the deposits. Oil shales are known in many parts of the United States. Those of the Rocky Mountains regions, in Colorado, Nevada, Utah and Wyoming, belong to the Green River formation of the Eocene; those of the Eastern States, stretching from Illinois, Missouri and Tennessee over to the Atlantic, are Devonian, and those of California of Miocene or Tertiary age. Technically the deposits have hardly any history so far, and none of the experimental plants have operated commercially. But matters are developing, some 70 processes having been proposed, showing a strong tendency to replace the Scottish vertical retort by horizontal and inclined retorts, and the big industrial and economic problems involved are being faced.

Heating and ventilation, as well as the acoustics and illumination of public and private buildings, have too long remained the step-children of applied science. The problems of illumination have properly been investigated of late, notably in England and in America. As regards acoustics we have in this country not advanced much further than to admit the justification of the complaints made about the acoustics of new halls, on which architects and engineers otherwise appear to have bestowed full care. With regard to heating and ventilation we hardly remember the publication of any new text book of general standing since 1912, when Mr. A. H. Barker brought out his "Theory and Practice of Ventilation." In one respect this is perhaps as well. For the published papers of recent years have rather shaken our belief in some old orthodox doctrines. Yet engineers have undoubtedly learnt to improve their heating and ventilating plant, their boilers, radiators, distribution systems for high and low-pressure steam, and those special features—to which Mr. Barker did not devote much attention—which have their particular application in factories, and which Professor Valerius Hüttig, of Dresden, deals in his "*Heizungs- und Lüftungsanlagen in Fabriken*" (Leipzig, Otto Spamer; price 10,500 marks plus 200 per cent.). The 414 large octavo pages of this second edition of the book are illustrated by many diagrams and tables. Professor Hüttig writes essentially for the engineer. He has naturally a good deal to say on the utilisation of exhaust steam; he does not refer to multiple evaporation, however, and his chapter on ventilation is far too short, even if we add to that chapter the separate sections on drying and on fume and mist removal.

Electrical engineers and others concerned with electrical matters in this country certainly cannot complain of the number of annual publications devoted to their interests. We have already noted many electrical pocket books in the last three months, and have now to add "*The Practical Electrician's Pocket Book*" to their number. This annual, which is edited by Mr. H. T. Crewe and published by Messrs. S. Rentell and Co., Limited, of 36, Maiden-lane, W.C. 2, has now been appearing for twenty-five years, and is very generally known and appreciated. It is compiled chiefly for the use of those practically engaged in the industries in which electricity plays a part, and there is little of the theoretical material which does not appeal to the shop man. The book consists essentially of a series of short articles each dealing with one branch of its wide subject, and as usual many of the sections have been re-written in order to keep them in current with developments. In the present issue this applies, for instance, to the sections on electric tools, motor control, electric welding, &c. An entirely new chapter has been added on the latest electric toy—broadcasting. The book runs to well over 500 pages, contains a diary, and is published at 3*s*. net.

Dwellers in Egypt, and even visitors to that country, are aware in a rough way of the difficult climatic features of the various parts of the Nile Valley and surrounding country. The difference between the conditions at Alexandria, Cairo and, say, Sohag, are so marked that even the casual observer, if resident for any length of time, will get to know what weather may be expected in any one of them. General impressions of this kind, in a land where climatic conditions are, so to speak, relatively steady, are very largely borne out by a work on *Climatological Normals* compiled by the Physical Department of the Ministry of Public Works of Egypt, and published by the Government Press, Cairo, at Pt. 20. This work gives a series of charts for Egypt, the Sudan, Abyssinia, &c., showing isobars and prevailing winds, month by month, for the year; isotherms are given in a similar set of charts, while monthly rainfall is given in a third series. Tabulated data follow for the recording stations. The book is not one, of course, for the general reader, but contains a lot of valuable data for the specialist.

A history in the Italian language of recent wars, and of the Great War, pointing out the absolutely necessary co-ordination between the land and the naval forces in any conflict, forms a most interesting and instructive addition to the literature on the subject. The book is entitled "*La Guerra Marittima, Studio Critico sull' Impiego dei Mezzi nella Guerra Mondiale*," by Sea Captain Romeo Bernotti, published by Messrs. Carpigiani and Zipoli, Florence, at the price of 30 lire. The volume we have received is volume I. The duty of each naval unit together with every means of attack and defence are reviewed in detail. Stress is laid both on the action of the navy in the recent wars which preceded the Great War, and in the latter. In the matter of the German Grand Fleet, this, the author says, formed a political instrument, a remark which is confirmed in another chapter in which he adds that "on July 5, 1914, the Central Powers decided to seize the Serajevo crime as an excuse for precipitating a crisis; financial considerations, however, made for delay, and whilst diplomacy was setting to work to render a new war inevitable, the German fleet was sent to Norway in the middle of July. Instead, therefore, of being reckoned upon as a powerful arm," (which it was, as is clearly emphasised in other parts of the book), "one capable of striking a first blow, it was used as a means for dissipating suspicion, and for contributing to the diplomatic trickery which was to facilitate the strategic surprise on land." The different engagements which took place on sea, the correlation—or as the case may have been, the absence of correlation between these and the engagements on land, the advent of the submarine, of the air forces, the extensive use made of mines, are all dealt with in great detail. The author points out occurrences both in the political realm and in strategy, the actual results of which, and the consequences they might possibly have had, give the reader furiously to think. The impression he will gather from the book is that in a future war the "new" means of offence, namely submarines, aircraft and also poison gases, are likely to be used more extensively than they were in the Great War. In regard to aircraft, "the sea, far from constituting now as in the past a protective barrier, favours on the contrary an "aerial surprise," allowing as it does the aircraft units to reach important coastal towns without being heard, such not being the case when they have to fly over enemy land for reaching their objective. Hence the greater the extension of the coast of any given country the greater risks it will run from the point of view of aircraft attack." This first volume of a most careful study on the lessons of former wars and of the Great War will repay careful consideration.

Webb's "*Railroad Construction*" needs no introduction to our readers, but many will possibly be glad to hear that a seventh edition of this standard work has just been published (Messrs. Chapman and Hall, Limited), at the price of 30*s*. net. The first edition appeared in 1899, since which time the work has been steadily improved. As the author points out, the valuable work of the American Railway Engineering Association has served to crystallise railway practice in several directions, and has resulted in certain standards being accepted. The author has wisely incorporated in his work the results which have thus followed from these efforts towards approved practice. In this edition a number of additions and revisions of chapters have been made. The chapter on yards and terminals has been re-written, and an entirely new one on stresses in the track has been added. As the years pass, the value of this work improves and it is still published in a handy, thin paper, leather-bound volume of very practical size and bulk, although containing about 850 pages.

Though electrical engineering is barely half a century old, and the term "electrotechnics" practically belongs to this century, so far as this country is concerned, electrotechnical science has undergone so amazing a development that one needs a library rather than a volume for looking up electrotechnical problems. But even the specialist wants a general introduction. Next to the student of electrical engineering, the engineer is particularly interested in the literature on the subject, because he must be prepared to keep his electric motors, electric lifts, light circuits, batteries and diverse electric instruments in working order. Both for the student and the engineer a compendium like the "*Lehrbuch der Elektrotechnik*," edited by Professor Esselborn, may be very useful. The volume (Leipzig, Wilhelm Engelmann; price 19·50 Swiss francs), deals in 753 octavo pages, illustrated by 924 text figures, with the general principles of electrotechnics, with electric measurements and with electric machinery and apparatus, including batteries. The compilers of the three chief divisions, Dr. K. Fischer, K. Hohage and G. W. Meyer, are all engineers who succeed in describing the main features without going too deeply either into mathematics or constructive detail. Bibliographical references will probably be more abundant in the second volume, which is to discuss special branches of electrical engineering.

MECHANICAL GEARING.*

By the Hon. Sir CHARLES A. PARSONS, Vice-President; STANLEY S. COOK (Member); and H. M. DUNCAN.

THE progress of the marine steam turbine has, as a result of the rapid developments of the last ten years, become identified with that of the means of transmission of power to the slow-moving propeller. Of the various means of transmission, mechanical gearing on account both of its simplicity and of its efficiency has been most widely adopted. Introduced primarily for the purpose of extending the field of utility of the turbine to the propulsion of low-speed mercantile vessels, for which the revolutions of the propeller were too low to make direct-coupled turbines an economical proposition, the advantages of freeing the turbine from the limitations to its revolutions imposed by the propeller was soon recognised to be of value even in those fields of work which were then open to the direct-coupled turbine, which has consequently been almost completely displaced in naval and high-speed mercantile work throughout the world by the geared turbine. Since their first experimental adoption in the Vespasian, a description of which was given in papers before the Institution in 1911 and 1912, the output of mechanically geared marine turbines has grown rapidly, and the total output has equalled and even surpassed that of direct-coupled turbines.

Of the total output in British-built vessels, about 10,000,000 h.p. has been transmitted with a single reduction in speed, and about 1,000,000 h.p. with a double reduction. Single reduction is chiefly used in naval work. It was recognised from the first that there were circumstances in a marine drive which made necessary a considerable margin of strength over and above what was calculated for the normal power transmitted, to cover possible inaccuracies in the gear cutting, lack of exact alignment, and shocks due to rough seas or even the striking of the propeller blade against a submerged obstacle, and to meet these contingencies such a margin was provided. The first gears were regarded as experimental, and increase to larger powers was made in cautious stages. The demand for quick production during the war led to an abandonment of some of this caution, but the record of geared turbines in the Navy during the war has shown that this confidence in mechanical gearing was not misplaced. In some instances the power successfully transmitted through a single pinion has been as high as 20,000 h.p., with tooth pressures as high as 1,100 lb. per inch of surface.

The gears for naval work have been almost exclusively single reduction, usually consisting of two pinions engaging with a common wheel on the propeller shaft. Where, however, geared cruising turbines have been fitted, the power of the cruising turbine has frequently been transmitted by double reduction, the cruising turbine being connected through a single wheel and pinion to the shaft of one of the main turbines, itself geared to the propeller shaft.

The largest ratio of reduction adopted with a single step from turbine to propeller shaft was 26 to 1 in the case of the Cairnross, a mercantile vessel built in 1912, which was sunk during the war. It was soon recognised that in mercantile work to obtain full advantage of the economy of high-speed turbines a still larger ratio of reduction was required, and this led to the adoption of double reduction gears. The development of mercantile work was, however, interrupted by the war, and it was not until 1918 that the first marine double-reduction gear was fitted in this country in the S.S. Somerset. This gear had teeth of $\frac{7}{10}$-in. pitch in the primaries with a load of 560 lb. per inch, and teeth of 1-in. pitch in the secondaries with a load of 982 lb. per inch, and this vessel has run a total distance of about 170,000 miles. Reference should, however, be made to a turbine-driven rolling mill fitted with double-reduction gear which was installed at Calderbank in 1910, and has run satisfactorily up to the present time. The load on the secondary teeth of this gear is 1,150 lb. per inch.

Since the time when the Somerset was placed on service there have been about 207 British-built vessels fitted with

* Abstract of paper read at the Spring Meetings of the Institution of Naval Architects, March 22, 1923.

double reduction, and during the same period 26 with single reduction. Unfortunately the excellent record established by the earlier gears has not been maintained. Commencing in December, 1921, there followed throughout last year repeated instances of failure of newly-installed gearing owing to the fracture of pinion teeth. There has been a general tendency to associate these failures specially with double reduction, but in reality the percentage of failures is no more in double than in single reduction in mercantile work during the same period. Out of 207 vessels with double reduction there have been 16 such cases of failure, and in single reduction 4 cases out of 26. So that whilst it may be recognised that the effect of inaccuracies in the teeth is likely to be greater in double reduction on account of the greater energy of the high-speed turbines, this cannot, in face of the facts, be accepted as the explanation of these failures. The design of the single reduction gears, too, must be acquitted when we take into account the mass of successful naval work with gears of similar type.

When the report came of the second of these failures by fracture, the authors and their colleagues immediately took up with the steel makers the question of the quality of the steel. Investigation of the physical characteristics and both macroscopical and microscopical examination of nickel steel pinions which had failed in this way showed considerable variation in grain size and in physical properties, but did not supply a sufficient explanation for these failures. In almost all cases the fractures were what are termed creeping fractures, consisting of a fine-grained area and a smaller coarse-grained area where the teeth finally broke away. Recent experiments by Dr. Hatfield have shown that such fractures can be produced by repeated stresses in one direction and well above the elastic limit.

In the very early experiments which led to the introduction of mechanical gearing, after the original gearing of the Vespasian had been well tried out, the original pinion was replaced by one of high tensile steel, with the result that several of the pinion teeth fractured on the first voyage. From this experience it was concluded that as a necessary requirement the steel must possess a high degree of ductility. As confidence grew, however, this rule has not been rigorously observed. The tendency has been to use harder steel, nickel steel, or chrome nickel steel, hardened by oil quenching, and it is with such steels that practically all the fractures have occurred.

Investigations have been made by the authors and their colleagues into the possibilities of producing cracks in oil-quenched nickel steel by heat treatment, such as might be employed in the ordinary process of manufacture.

The nine samples experimented upon were all portions of turbine reduction gear pinions of cylindrical shape, from 8 in. to 12 in. diameter, and from 8 in. to 10 in. long. The dimensions of the samples, and of the finished pinions from which the samples were cut, are shown in Fig. 1 annexed. It will be observed from these that some of the pinions have central holes. Except in the case of sample No. 4 these were bored and all rough machining done before oil quenching by the makers. The makers' heat treatment of the forging from which each sample was taken, where known, is stated in Table I on page 410.

Six of these pinions had actually been for some time in service. Of the three others, one was rejected through an error in machining and two were replaced through a change in design. The material in all cases was nickel steel to the usual specification, viz., carbon 0·25 per cent. to 0·32 per cent., nickel about 3½ per cent.

The heat treatment in these experiments consisted in heating the sample to a high temperature in a gas-fired furnace, and either quenching it in oil or allowing it to cool out in the atmosphere on a steel plate on the shop floor; the procedure generally followed was to subject the samples to a series of such treatments alternately, quenching from 850 deg. C., reheating to 600 deg. C. for tempering, and cooling in air. The initial temperature of the furnace on the insertion of the sample was varied, and in some instances the sample was enclosed in a muffle.

Temperatures were observed by two pyrometers, one of the ordinary thermocouple type in which the couple was inserted in the furnace and therefore gave the temperature of the furnace itself. The other a radiation pyrometer which was focussed on the sample or enclosing muffle and therefore indicated the temperature of the latter. The accuracy of these instruments was verified during and after concluding the series of experiments.

After each treatment the samples were examined for cracks, and to facilitate this the plain surfaces were, in the majority of cases, ground or polished. Table II on page 410 gives a general summary of the experiments, and Tables IV to XI of the Appendix the detailed records of the heat treatment of the various samples.*

Sample No. 1 was from a pinion which was spoiled through an error in machining, but which would otherwise have gone into service since it had passed the prescribed mechanical tests. This sample was subject to two quenchings and one tempering. After the second quenching it was found that the sample had developed a large number of cracks on the flat ends. The cracks can be seen in the photographs, Fig. 2 annexed. The sample was then annealed and cut up for examination, as indicated by the dotted lines in Fig. 1, and photographs Figs. 3 and 4 on pages 410 and 411 show the cracks as they appeared in the various sections.

Samples No. 8 and No. 9 were from a high pressure primary pinion of a double reduction set of gears, one sample being taken from each helix. This pinion had been on service about six months but had not failed or been damaged in any way beyond a certain amount of pitting. The l.p. pinion, however, which was from the same maker and presumably from the same cast, had failed by tooth fracture and was re-sleeved. It was therefore considered advisable to replace the h.p. pinion also, and this left the original pinion available for investigation.

The samples No. 8 and No. 9 were subjected together to six quenchings and eight temperings. Three or four cracks appeared on one end of sample No. 8 after the third quenching. One of these was radial and the others principally radial. For the next heat treatment these two samples were heated in the furnace at a temperature of 600 deg. C. and then allowed to cool out in the atmosphere, when two additional cracks were found to have developed in No. 8 and two radial cracks in one end of sample No. 9. The cracks in sample No. 8 are shown in the photograph, Fig. 5 on page 411. After the seventh quenching another small crack appeared at the other end of sample No. 8 and two cracks more in sample No. 9.

Thus cracks have been produced in three samples out of nine submitted to experiment by such heat treatment as nickel steel forgings are liable to be subjected to in the course of manufacture. Some of these nine samples were from pinions which had failed by tooth fracture, but it should be observed that the three in which cracks were produced had not actually broken, one of them never having been in service. It should be observed

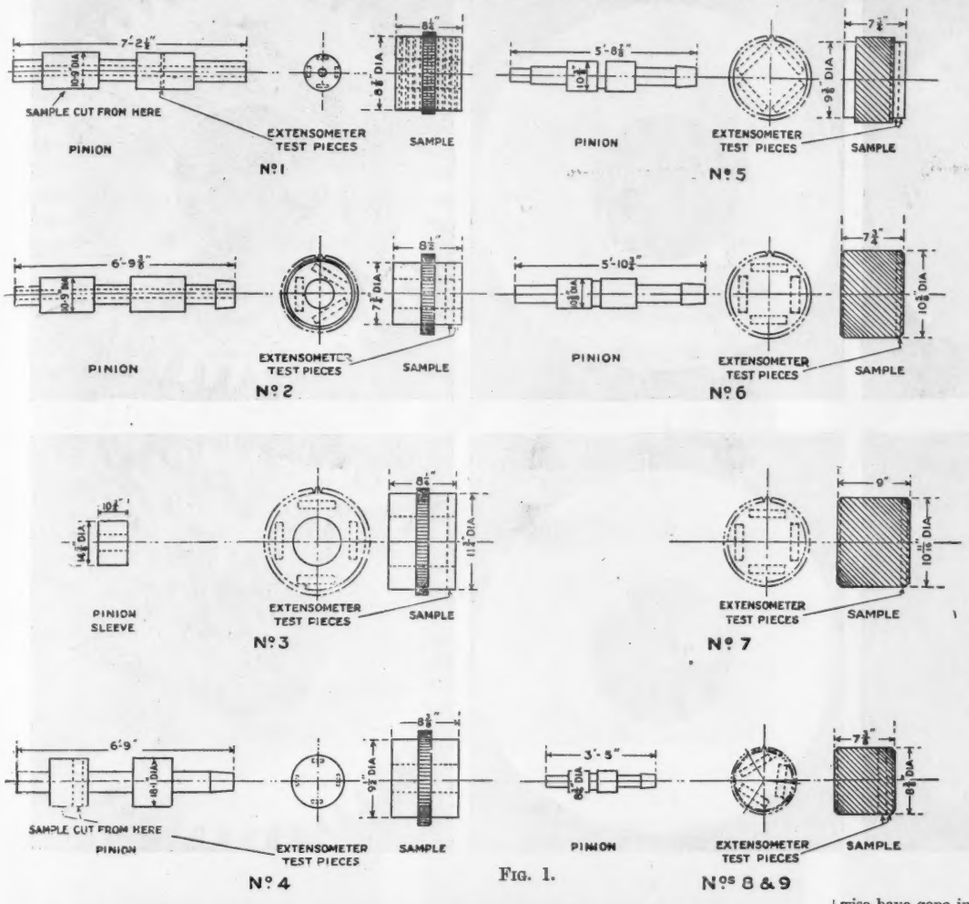


FIG. 1.

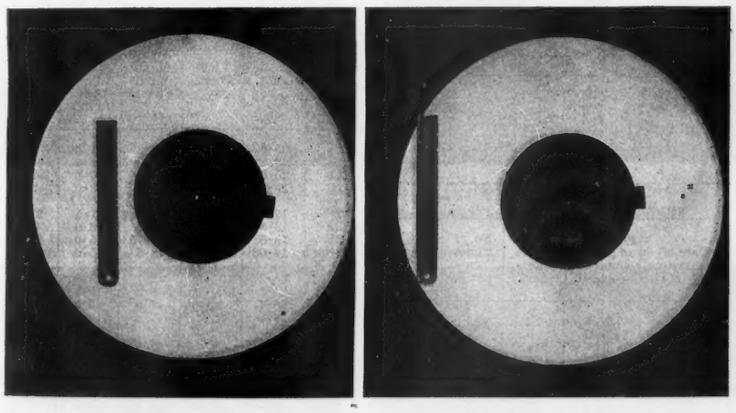


FIG. 2.

* Owing to pressure on our space we regret we cannot reproduce the tables in the appendix.

also, that all these pinions had passed their specified mechanical tests, but obviously test-pieces afford no indication of the state of internal stress.

Fig 6, on pag 411, is a series of micro-photographs from sample No. 1 : A before the experimental heat treatment, and Cook's paper in 1921. In an experiment, static loading 40 to 100 times in excess of the normal tooth pressure failed to break the teeth. The authors have in hand at the present time a further experiment to determine the maximum safe load per inch under steady

the two sides synchronise, it is possible for one pinion to be tending to push the wheel ahead, and for the other to hold back, and there is thus a state of war between the pinions with the inertia of the turbines behind them striving to keep them running at constant speed. To

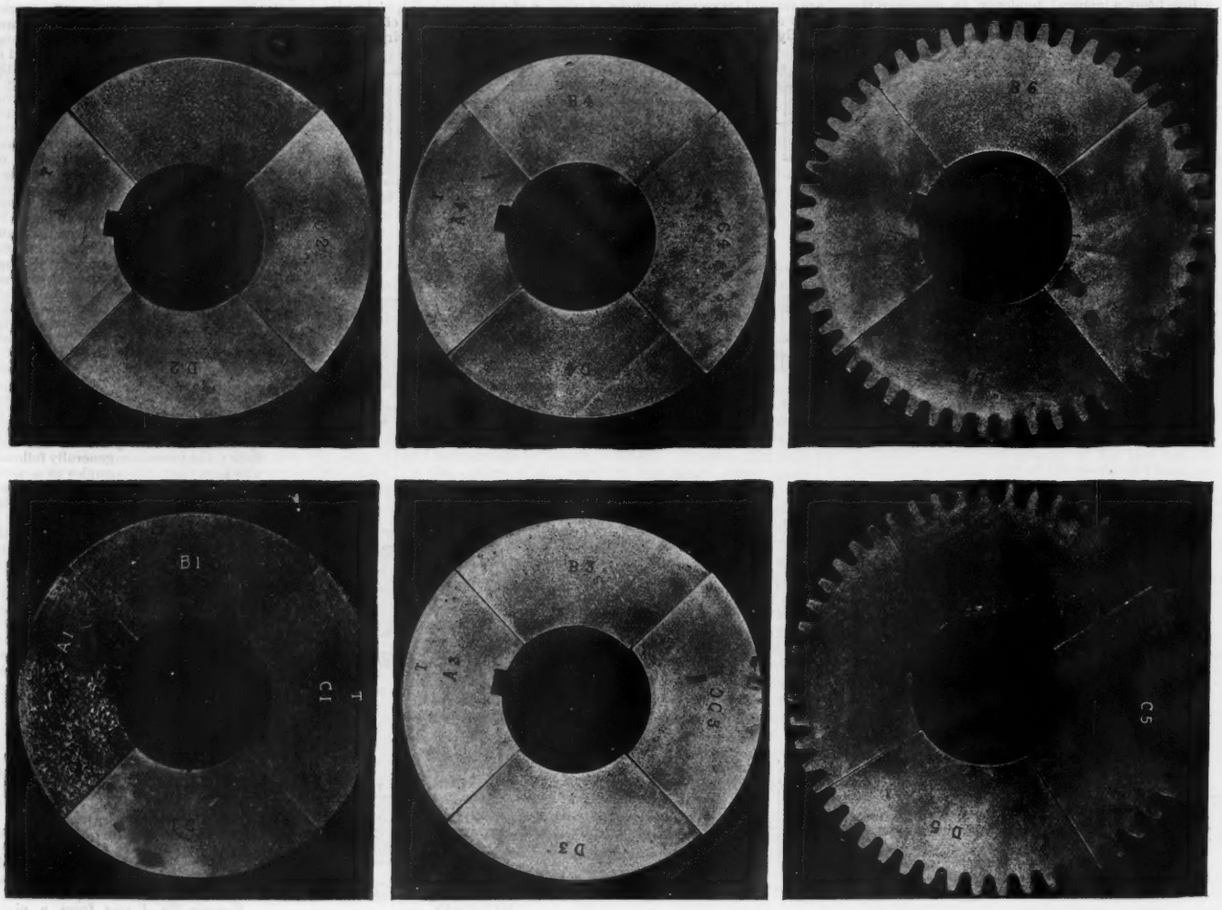


FIG. 3.

B from portion A9 (Fig. 4) away from the cracks, and C from the same portion showing cracks. With regard to the last two, it should be stated that the sample from which they are taken had been annealed before cutting up. Microphotographs from sample No. 4 are shown in Fig. 7 on page 411 : D as it was after having undergone only the maker's heat treatment, E and E1 after the series of quenchings and temperings recorded for that sample.

Extensometer tests have been made with transverse test-pieces for each of these samples, in the case of No. 1 and No. 4 from another part of the body of the same forging, in the other cases from the samples themselves after the experimental heat treatment.

The results are given in Table III and show considerable variation in proportionality limit, elongation, and reduction of area.

The heat treatment of nickel steel forgings is liable to produce in them strains of extreme severity. The exact nature of the strains it is not easy to determine. Were it only a question of simple expansion or contraction with varying temperature, the sudden cooling of the outer surface while the core is still hot will put that surface for the moment into a state of tension which the subsequent contraction of the core would reverse, and ultimately there would be compression strain on the surface and tensile strain in the interior. The action, however, is complicated by the changes of volume at recalescence points, first beneath the cooled surface and then gradually farther in, and varying strains and stresses are set up in all parts of the pinion. Heavy stresses may thus come upon some portion of the steel when it is at such a temperature as to be in a brittle condition and result either in a crack or in permanent injury to the steel.

The conclusion of the authors is that oil quenching of large masses of nickel steel introduces risks of cracks and excessive strains, and should be discontinued for turbine gears. The wheel rims are not made of oil-quenched steel, and the freedom from fracture of wheel rim teeth, and of those of pinions which have been normalised only, confirms this conclusion.

With steel in a homogeneous unstressed condition the factor of safety is a large one. Reference was made to this in the reply to the discussion on Messrs. Walker

TABLE I.—*Records of Heat-Treatment by Makers.*

Sample No.	Quenched at	Tempered to
	°C.	°C.
1	770	620
2	850	600
5	870	650
8	870	650
9	870	650

TABLE II.

Sample No.	Date of Manufacture.	Percentage of Nickel Content Specified.	No. of Times Quenched.	No. of Times Tempered.	Cracks Developed.
1	1917	3¼ to 3¾	2	1	Yes
2	1917	3¼ to 5	5	5	No
3	1911	3¼	4	4	No
4	1912	3¼	17	16	No
5	1920	3¼ to 5	12	13	No
6	1920 or 1921	3	7	7	No
7	1921	—	12	12	No
8	1919	3¼ to 5	8	8	Yes
9	1919	3¼ to 5	8	8	Yes

running conditions ; but in the early experiments made prior to the installation of geared turbines in the Vespasian, to determine the load at which destructive wear begins to take place, the limit was found to be about 1,200 lb. per inch with a 5-in. pinion, or 240 times the diameter of the pinion in inches. This limit varies directly as the diameter of the pinion.

The foregoing consideration of these matters does not imply a neglect of others which are recognised to be of great importance for the successful running of mechanical gears—chief of these is the question of accurate machining in particular the cutting of the teeth. The principal effect of an error in the cutting of the teeth is as follows : With two pinions driving one wheel, unless the errors on

TABLE III.—*Extensometer Tests.*

Sample No.	Elastic Limit.	Yield Point.	Maximum Stress.	Elongation, Per Cent. (2 in.)	Reduction of Area, Per Cent.	
1	25·0	36·6	46·2	21·0	36·4	
1A	26·0	30·0	46·0	24·0	42·7	F.*
1B	26·0	30·8	45·7	25·0	41·2	F.
1C	19·7	29·3	34·0	3·0	2·8	g.
2	19·6	41·6	47·1	21·5	37·5	
2A	13·5	29·7	47·1	20·0	30·6	F.
2B	13·5	32·5	48·75	15·0	23·3	F.
2C	14·06	32·5	48·5	15·0	33·4	F.
3	26·9	31·7	47·1	18·5	39·0	F.
3A	24·1	29·7	45·2	19·5	41·4	F. sl.
3B	28·4	32·4	47·6	20·0	38·0	F. sl.
3C	28·0	32·4	47·8	19·0	34·6	F.
4	18·6	37·9	44·6	20·0	33·0	
4A	19·3	24·9	45·5	12·5	11·6	g.
4B	15·65	24·5	45·2	12·5	11·6	g.
4C	18·0	24·5	45·0	10·5	13·7	g.
5	26·8	37·6	45·2	19·0	27·6	
5A	22·5	28·9	45·5	23·0	38·2	F. sl.
5B	26·1	30·1	46·3	21·0	38·1	F. sl.
6	31·6	42·7	50·6	15·0	26·7	
6A	30·5	40·5	51·1	15·0	30·5	F. sl.
6B	28·5	39·7	51·8	12·5	20·4	F. sl.
6C	32·2	43·5	53·7	12·5	17·5	F. g.
7	32·0	43·4	57·6	18·0	48·0	
7A	—	43·4	52·5	19·5	53·8	F.
7B	34·8	44·0	53·8	18·5	46·4	F.
7C	30·1	39·4	50·7	21·0	51·0	F.
9	17·4	31·6	40·7	24·3	37·0	
9A	18·4	25·6	41·32	22·5	36·0	F.
9B	19·3	27·7	42·3	18·5	35·0	F.

* Fractures :—F. = fibrous ; g. = granular ; sl. = silky.

overcome this it has been proposed in some cases, where errors are known to exist in the cutting machine, to mark the pinions and primary wheels in reference to their position on the machine when cutting, and subsequently in assembling to "register" the pinions and primary wheels on one side with those on the other, so that whatever errors of angular position may come to them from the gear-cutting machines may synchronise. This has actually been done in a few instances with marked success, as judged by quietness of running. It does not, however, counteract errors in the secondary wheel. A better proposal, however, is to insert flexibility combined with damping between the main wheel and the turbines, or at any rate between the turbines. A method of doing this was described during the discussion on Dr. Smith's paper last spring. By the courtesy of Messrs. Alfred Holt and Co., it is being fitted to one set of gears of a twin-screw vessel which will shortly go into service, and actual experience of such a provision will soon be available. With devices of this kind a larger error in the gear teeth can be tolerated. Without them, a higher standard of accuracy is required to obtain quiet running gears, and it is appreciated that no effort should be spared in the improvement of gear-cutting machinery.

At the same time, the gear-cutting machines as they are at present must be credited with a very high percentage of successful gears, and in the authors' opinion most of the instances of gears being unsatisfactory, through noise, for instance, should be attributed to want of care either in overhauling the machine or in setting the work rather than to inherent errors in the master wheels of the machines. Perfect accuracy is an ideal. The question may be approached from two stand-points: How far is it necessary to go? In other words, What is the maximum error that can be allowed? Or, How far is it possible to go in the direction of accuracy? What is the minimum of error that can be attained? To this latter question the Parsons Marine Steam Turbine Company are giving very close attention, and have in hand at present improvements which will further increase the accuracy of their machines, and by these means it is hoped to reduce the maximum error of angular position for large wheels to about $\frac{1}{2000}$ in. Regarding this as the accumulated error due to variation in pitch, it will represent an individual pitch variation (which is frequently adopted as the measure of accuracy) of the order of $\frac{1}{100,000}$ in. Two lines of advance are being followed, one involving a minute rectification of master wheels, while the other is the development of an improved creeping mechanism.

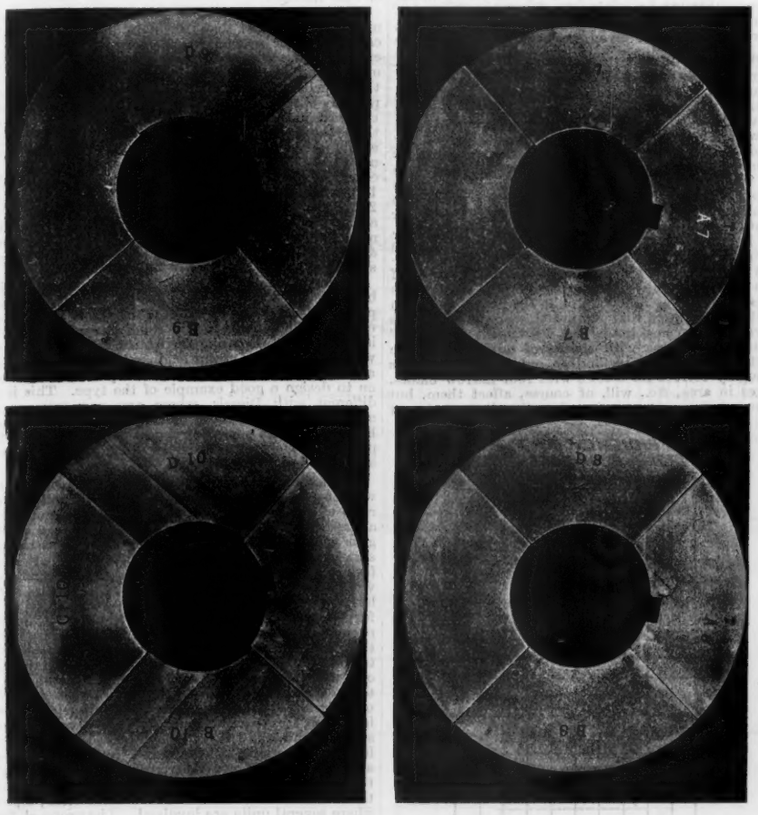


FIG. 4.

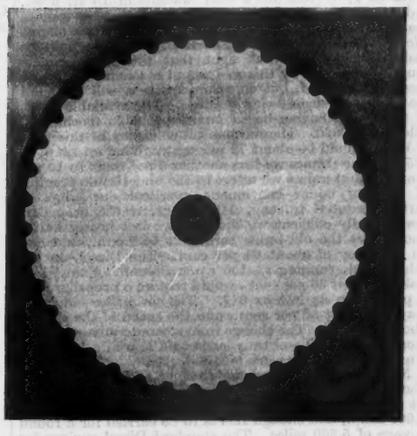
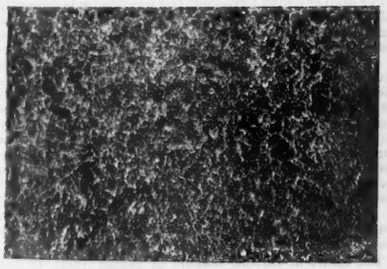
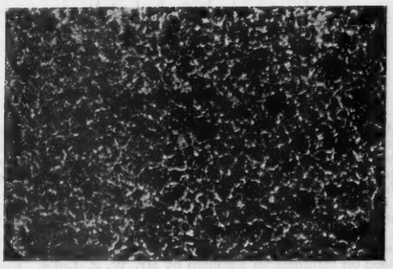


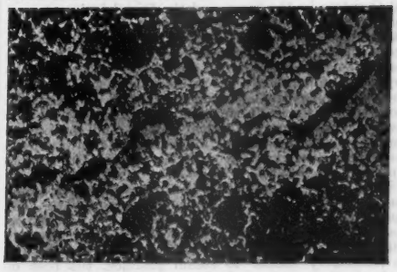
FIG. 5.



A.—SAMPLE NO. 1, MAKER'S HEAT TREATMENT.

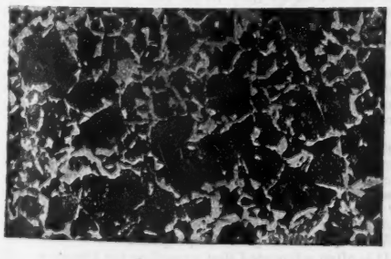


B.—SAMPLE NO. 1, AFTER EXPERIMENTAL HEAT TREATMENT. (SECTION A9 OF FIG. 4.)



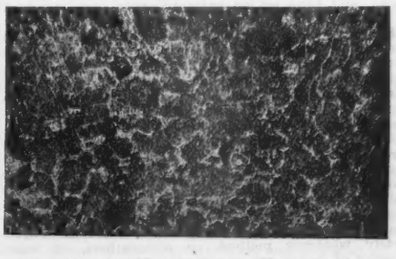
C.—SAMPLE NO. 1, WITH CRACK DEVELOPED. (SECTION A9 OF FIG. 4.)

FIG. 6.



D.—SAMPLE NO. 4, MAKER'S HEAT TREATMENT.

E.—SAMPLE NO. 4, AFTER EXPERIMENTAL HEAT TREATMENT.



E1.—SAMPLE NO. 4, AFTER EXPERIMENTAL HEAT TREATMENT.

FIG. 7.

THE POWERING OF MOTOR SHIPS.*

By Mr. K. C. BARNABY, B.Sc., Member.

IN this period of depression the motor ship occupies a very special position, to which it would not easily have attained in more prosperous times. The owner is searching for a more economical ship that will enable him to compete favourably with less progressive rivals. The builder knows that almost his only chance of obtaining orders is to offer something that will give very marked and peculiar advantages over existing tonnage. These feelings, together with the great success of so many motor ships, and helped by the prominence given to some geared turbine failures, have combined to shed a veritable halo over the marine oil engine.

Nor does the perusal of the energetic periodicals that are devoted to pushing motor ships lead one to suppose that under any conceivable circumstances could a Diesel (for simplicity of language the term "Diesel" will be used to cover any type of marine engine burning heavy oil) fail to show immense advantages. This is all very well, but it will be exceedingly unfortunate if it leads to fitting Diesel engines under unsuitable conditions. The resulting failure, or partial failure, can only tend to retard progress. As an illustration—an admittedly extreme one—of the danger of fitting a radically unsuitable engine, consider the following case. A small single-screw cargo steamer is employed on a coasting service in the tropics. She is 220 ft. b.p. by 33 ft. beam, displaces 2,440 tons on a load draught of 15 ft. 6 in., and steams 9 knots with 650 i.h.p. It is desired to replace the steam machinery by a Diesel, and the stock engine offered is rated at 675 i.h.p at 155 r.p.m. It might be rashly assumed at first sight that the steam engine could be replaced by this motor and a somewhat similar speed be obtained, but on examination it will be found that this is far from being the case. The available s.h.p. of the steam engine based on its probable mechanical efficiency is 52C. The mechanical efficiency of this type of Diesel would be about 72 per cent., giving an s.h.p. of 485. In the tropics we lose another 5 per cent. to 10 per cent., so that unless we resort to the undesirable practice of running under continuous overload our s.h.p. is further reduced to, say, 440. Thus, if the propellers were equally efficient we should have lost nearly half a knot. But the old screw turned at 66 r.p.m., and had an efficiency of about 64 per cent. The Diesel, on the other hand, running at 155 r.p.m., assuming the same wake value of 30 per cent., would require a propeller with a pitch-ratio as low as 0·7. The propeller efficiency may be put at 52 per cent., and the speed of the ship at about 7¼ knots. The change from steam to an apparently more powerful Diesel thus leads to a loss of a knot and a quarter, or 14 per cent. in speed.

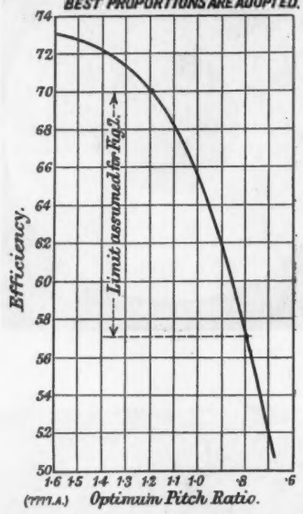
Now take the case of a passenger and cargo boat of about 9,000 tons' displacement and designed to make 14 knots. The machinery is to be twin screw of about 5,000 s.h.p., and enough fuel is to be carried for a round voyage of 5,500 miles. The standard Diesel engines for this total power would run at about 90–115 r.p.m., so that a good propeller efficiency can be obtained, and one quite equal to that with any steam plant. The s.h.p. will therefore be the same, and the Diesel fuel consumption can be put at 0·42 lb. per s.h.p. hour, against 1·1 lb. with oil fuel, and double-reduction geared turbines. This means that the Diesel ship will consume nearly 600 tons less fuel on the voyage and carry over 500 tons more cargo, even allowing for the rather greater weight of the machinery. Or, if the amount of cargo is fixed, the Diesel ship can be made smaller and finer, with less power. The economy will then be still more marked, as the first cost will be about the same and fuel costs not much more than half, even when allowing for a more expensive grade of oil.

So in the latter case there is a clear gain with Diesel machinery, and in the former an equally clear loss. Apart from questions of reliability and maintenance, etc., that are outside the scope of this paper, the real criterion is that of propeller efficiency. Unless this can be reasonably similar to steam practice, the best oil engine in the world may be less suitable than a relatively extravagant steam engine. In any case, it cannot show to full advantage, as fuel economy is after all the *raison d'être* of the Diesel, and on this it must stand or fall. For cargo boats this question of propeller efficiency is particularly important. Reciprocating engines are cheap, and have set an extraordinarily high standard of reliability.

Fig. 2 is an attempt to produce a diagram that will show at a glance whether a particular engine is suitable or not for any proposed ship. It is based on the following data:—Propellers for motor ships have usually four narrow blades, and their efficiency is about as shown in Fig. 1, always providing that the pitch ratio is the best possible for the conditions (see Note "A" in Appendix). Below 0·8 pitch ratio the efficiency becomes too low for ordinary purposes. Above 1·2 pitch ratio, though the efficiency is still improving, the Diesel has become unnecessarily heavy and should be speeded up. These values will therefore form approximate limits of suitability. The problem is, then, to connect these limits with power and revolutions for various speeds of advance. Fortunately whatever method, or elaborations, or exact niceties of design are employed in calculating the propeller, we cannot get far away from a certain basic relation between these quantities, that will remain comparatively unaffected.

Thus Taylor's propeller charts are based on a function ρ = r.p.m. $\times \sqrt{\text{s.h.p.}} \div V_a^{2 \cdot 5}$, where V_a = speed of advance of screw. The constants in Mr. S. W. Barnaby's tables are inter-connected by the "Wingfield Value" K, which = i.h.p. $\times R^2 \div V^5$, or about $1 \cdot 175\ \rho^2$. Froude's figures are connected by a relationship that can be reduced to the inverse of ρ or K, and on these values, in whatever form they may be put, depends the optimum pitch ratio that can be employed. Assuming, then, that we can adopt this optimum pitch ratio, or, in other words, that we can work the given screw at its best slip, we can write, Revolutions = Constant $\times V_a^{2 \cdot 5} \div \sqrt{\text{s.h.p.}}$ Put into logarithmic form, it becomes log r.p.m. = Constant $+ 2 \cdot 5 \log V_a - \frac{1}{2} \log$ s.h.p., and is the equation to a straight line, as in Fig. 2. Here the lines represent the revolutions corresponding to any given power when a screw of 0·8 pitch-ratio is working at its best efficiency and advancing at speeds of 6, 7, 8, &c., knots. But any line represents equally well any other pitch-ratio screw which is advancing at a speed corresponding to its best efficiency for the power. As 1·2 pitch-ratio was taken as our upper limit, the speeds of advance for this ratio have been calculated as shown on the diagram. Thus line "A" represents the relationship between power and r.p.m. when a 0·8 pitch-ratio screw is advancing at 6 knots, or a 1·2 pitch-ratio at 8·8 knots, or of course intermediate values. Any engine which falls on this line, such as a 400 s.h.p. at 100 r.p.m., will then be suitable for ships that require this power for speeds of advance between 6 knots and 8·8 knots. Line "B" is suitable for ships with speeds of advance between 7 knots and 10·3 knots, and so on. The revolutions are roughly correct for screws with four narrow blades. Changes in area, &c., will, of course, affect them, but not enough to matter, seeing that the diagram is not intended for actual propeller design, but only to indicate the approximate limits within which a good one can be designed. The revolutions have been worked out from the curve of "K" values given in S. W. Barnaby's *Marine Propellers*, 1921 edition.

Fig. 1. EFFICIENCY FOR TYPICAL DIESEL PROPELLERS WHERE BEST PROPORTIONS ARE ADOPTED.



(7777.A.)

Before using the diagram it is, of course, essential to estimate the wake speed and deduct it from the speed of ship, so as to get the speed of advance on which it is based. For this purpose we can use Taylor's equations based on information supplied by Mr. W. J. Luke. For convenience of reference the values are repeated in Fig. 3. While it cannot, of course, be strictly accurate to base wake value on block coefficient alone, it gives a close enough approximation for ordinary purposes. As motor screws are usually relatively small in diameter, single screws are likely to be operating in rather stronger wake than indicated, and twin screws, if they have big clearances, in a rather weaker one. On examining Fig. 2 it will be noticed that the Sulzer range very closely follows line "C," except in the larger powers, and is beautifully graded for propeller efficiency. It is also clear that with this make it is usually immaterial if the machinery is single or twin screw. Thus the 800-b.h.p. model or two 410-b.h.p. engines are equally suitable for the same pitch-ratio, and give the same efficiency. Another point is that for the medium-power Sulzers, the best pitch-ratio is usually about one-tenth of the speed of advance.

It will be noticed that the only engines plotting below line "B" are the long stroke Burmeister and Wain, a Werkspoor, and a Fullager, and these are all close to it. With the makes of oil engines at present on the market, it can therefore be definitely said for reasonable propulsive efficiency, no ship should be designed with direct transmission for a less speed of advance than about 7 knots. The upper limit will be about 15 knots, above which the standard engine becomes unduly heavy and should be speeded up.

The range of Diesels in actual service, or manufacture, will be seen to be suitable for all cargo boats of any size or power, provided they are designed for not less than about 10 knots' sea speed. The engines are also very suitable for intermediate mail and passenger boats. For the fastest types the regular engines are a little slow. It will be noticed that the big Ansaldo and Sulzers are relatively faster running. This is as it should be for ships of 17–18 knots, like the new 20,000-ton Fairfield-Sulzer liner building for the Union Steam Ship Company of New Zealand.

There are, of course, very many highly successful motor ships of less than 10 knots' speed, but in these cases the poor propulsive efficiency is masked by the extraordinary economy of the engine. All that is claimed on this point is that if the ship is under about 10 knots the propeller efficiency will be poor, and the Diesel cannot possibly show its full economy. Where there are special circumstances enabling full advantage to be taken of the reduced "standby" losses of a Diesel, it will pay to accept a reduced efficiency, and the 10-knot limit does not apply. With steam tugs of 300–500 i.h.p., for example, the revolutions would usually be round about 130, whereas similar power Diesels would average 175–250 r.p.m. As the actual working hours of most tugs are few, it will usually be more economical to install the more powerful Diesel. For vessels such as fire floats, &c., the Diesel is also clearly indicated as much the most suitable type.

It may be argued that the revolutions of a Diesel can be altered in the same way that the designer of a steam plant will adjust the r.p.m. of his engine to suit the speed of ship. There is certainly some latitude, particularly in the way of increasing the r.p.m., but not so much as with reciprocating steam engines. Moreover, the latter are so standardised that almost any firm can be relied on to design a good example of the type. This is very different with Diesels, where any new type or even alteration calls for more or less elaborate experiments. Probably in the course of time this will change, but at present the shipowner should go carefully and adopt standard and well-tried types.

Reduction gearing, whether mechanical or electrical, will, of course, overcome the propeller difficulty. As the ratio of reduction need only be small, and nothing like as great as with turbine jobs, a single reduction mechanical gear would usually seem the best solution as being the simplest and cheapest. At any rate, it seems better suited for the small and slow cargo-boats that in general are the vessels that stand most in need of gearing. For the largest and fastest ships there can be no possible case for electric transmission on the ground of improved propeller efficiency. For instance, as deduced from Fig. 2, that for the new Fairfield-Sulzer liner already referred to will be exceedingly good, and could hardly be improved on. The advocates of electric propulsion should base their claims on the securing of lighter and simpler Diesels of a faster running and irreversible type with greatly improved manœuvring powers. Here they are on more solid ground, the Diesel, though not so bad as the absolutely irreversible turbine and requiring a separate astern engine, is not inherently a good reverser. So that the idea of a single master switch that will control the whole vessel has undoubted attractions, especially where several units are involved. The proposal, though seriously mooted in some quarters, that such a master switch could be located on the bridge, is more fanciful than practical.

For double-ended ferries electric propulsion is especially valuable in enabling all, or almost all, the power to be concentrated on to the aft screw, and thus avoiding the inefficiency of a driving bow propeller. The elimination of so much shafting that is often claimed as one of the advantages of electric propulsion is a rather illusory one. If the Diesel engines are amidships and the motors aft, with a narrow tunnel for carrying the cables and for communication, this will cause almost as much broken stowage as the usual wide tunnel, since the height will be much the same. If, on the other hand, the tunnel is abolished and the cables led along or under the deck, this divides the engine-room into two separate sections, with resulting difficulties in efficient supervision. It is only in special cases such as small cargo boats, tankers, or ore-carriers that it is usually possible to arrange all the machinery aft owing to difficulties of trim.

The habit of certain makers of rating their engines in i.h.p. has already been mentioned. Unfortunately the mechanical efficiency of Diesels varies immensely, according to the auxiliaries that are directly or independently driven. Thus sister ships may have engines of the same make, cylinder dimensions, r.p.m., and i.h.p., but which differ by fully 10 per cent. in actual or useful output. It would seem very desirable to quote powers in b.h.p. As regards the fitting of single or twin-screw machinery, Fig. 2 will serve as a general guide both as to the engines that are available for a given power and the probable propulsive efficiency. Strictly speaking, there are, of course, many other considerations than propeller efficiency alone in comparing single with twin screws. In practice, however, the increased resistance of the twin-screw bossings or struts, together with the rather greater hull efficiency of single screws, is usually just about offset by the loss in propeller efficiency of the latter due to the slower speed of advance. In ordinary cases we can therefore compare single with twin screws by taking a speed of advance appropriate to the latter and finding the efficiency on this basis. This will be sufficiently close for practical purposes.

It is often advocated that propellers for Diesels should be designed to absorb the full power at just under the normal r.p.m. This, except for auxiliaries, boats usually travelling half their time in ballast, or engines that are extravagantly fast, seems hardly desirable. It means that the engine will never reach its rated r.p.m. unless overloaded. When turning at, say, 15 revolutions less than normal, it will really be working just as hard, as the bearing pressures will be identical, if not greater. In order to ensure long life it should be possible to run the engine at full rated speed, and then to deliberately ease it down to a slightly lower service speed. It will then

*Abstract of Paper read at the meeting of the Institution of Naval Architects, March 22, 1923.

be running under quite different conditions than when forced down to the lower speed by an over-large propeller. This is particularly important in the tropics, where the conditions are especially severe, and there is a serious loss of power amounting to from 5 per cent. to 10 per cent. With regard to this loss, trial reports have been issued apparently denying it, as they purport to show a normal or even slightly greater output under tropical conditions. But what this really means is that the engine will develop considerably more than its rated power in a cold climate, and the margin is enough to cover the less favourable circumstances of a hot sea and a superheated atmosphere.

Experience gained with many different makes and sizes of engines for boats of the Costeira Company has shown it to be absolutely essential to allow for this reduction in power. It applies not only to Diesels, but to hot bulb engines, petrol motors, and in fact all internal-combustion engines. The boats of this company operate mainly within the tropics, and emphatically the engines do *not* develop their rated power at their rated speed. Incidentally this enterprising Brazilian concern is in perhaps the unique position of designing, building, and operating its own motor ships. One of these is the new twin-screw motor ship Itaguassu. She has two 520-b.h.p. Sulzer Diesels, which are expected to deliver a total of 925 b.h.p. in service and give about 10 knots. Diesels are especially suitable in the tropics, as ensuring a cool engine-room, while the elimination of boiler uptakes or casings, coal chutes, &c., enable improved passenger accommodation to be arranged.

Owners who are ordering new passenger ships would do well to insist on seeing a curve showing the range of stability rather than figures for initial G.M. in various conditions. The ever-increasing superstructure of modern ships on practically the same load draught means that the C.G. tends to become higher and higher in relation to the water surface. Now the higher this is, the more difficult it is to turn out a really good sea boat. It is easy enough by increasing the beam to get any desired initial G.M. without the use of water ballast. The trouble is to obtain a satisfactory righting lever at a considerable angle of heel without an excessive initial G.M. A case has been worked out in the Appendix (*Note B*) to show that a low C.G. ship may have a small G.M. and be comfortable, yet absolutely safe from capsizing in any storm, while a similar ship with higher C.G. and a big initial G.M. may be not only uncomfortable, but even unsafe in heavy weather. Perhaps the author ought to apologise for bringing forward this very self-evident matter. He ventures to do so because, outside technical circles, there is such a widespread idea that G.M. *per se* is the proper measure of a ship's safety, whereas what it really indicates more than anything else is the probable amount of sea-sickness among the passengers.

Probably a majority of those who are accustomed to the sea will agree that a narrow-beamed old-timer, with low superstructures, or a present-day "intermediate," is often a better sea boat than a modern "last word" liner, with her high sides and decks. The claims of suitable lines for comfort at sea, minimum resistance, and minimum weight are sometimes rather conflicting. An attempt has been made to combine the two former by "bulges," as in the Cap Polonio. This solution is not altogether desirable as it is costly, and calls for many outlet pipes to be carried through two hulls and made tight in each. It, of course, makes boat lowering in a seaway more dangerous than ever. Motor passenger ships are especially suitable for working with a fine initial G.M., as the comparatively small amount of fuel can be easily compensated for by admitting water ballast. At any rate, they are better off than coal burners, with a necessarily large change in C.G. during the voyage.

When calculating the power for a new Diesel ship the designer usually has a somewhat similar steamer to guide him. By correcting for the differences in mechanical and propulsive efficiency he can arrive at a fairly close estimate. The margin of trial speed over sea speed need not, however, be so great as with a coal-fired ship. The latter usually never again obtains her trial speed when once handed over. The oil engine seems less susceptible to the expert handling of "trial parties," and owing to initial stiffness often improves in power after several months' careful running. Where there are no available data for a similar steamer, and in the absence of a tank, one may have to rely on an independent estimate of power. Here Admiral Taylor's charts are often of very considerable assistance, but they must be handled with great caution. It is obvious that they cannot be used for types greatly differing from the parent form. It is therefore a matter of interest to know where to draw the line, and with this object the author has examined several hundreds of cases.

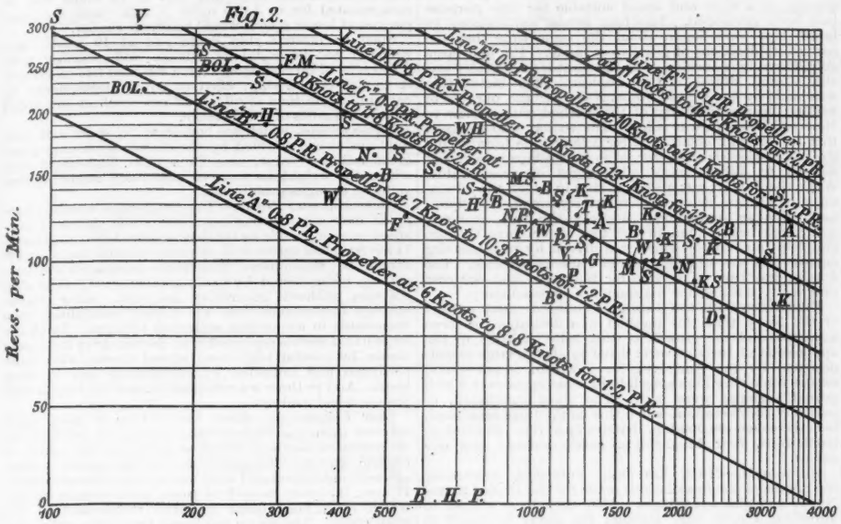
The results can hardly be dealt with here, but the general conclusion is that for the faster cargo boats and for intermediate mail and passenger boats of fair size, they give astonishingly accurate estimates. For all other types, and particularly for small craft, they could not be relied on at all. What it means is that for the former types the lines usually closely approximate to those experimented on, whereas in the latter instances they do not. Where useless for absolute results, the charts, however, are often of service in estimating the effect of slight changes. When consulting these charts and other published tank records to find the nearest approach to a proposed design, there is at once the old difficulty of the difference of English and American methods in recording results. Both systems have special advantages. The Froude Constant method gives the whole power at once, and as it is practically the Admiralty coefficient inverted, is familiar and easy of handling. The American method of plotting residuary resistance separately in "lb. per ton of displacement" is more convenient when examining the effect of changing dimensions. It also avoids some of the confusion due to various experiment tanks using slightly different frictional coe cients.

Personally the author finds it convenient to record his private data in a modified form by splitting up (C) into two parts. These correspond to the frictional and the residuary h.p. That is, $(C) = (C_F) + (C_R)$, where $(C_F) = 427{\cdot}1$ f.h.p $\div \Delta^{2/3} V^3$, and $(C_R) = 427{\cdot}1$ r.h.p. $\div \Delta^{2/3} V^3$ f.h.p. and r.h.p. denoting the frictional and residuary parts of the total e.h.p.

The relation between (C_R) and Taylor's residual resistance per ton ("Rr") is then simple, viz. $(C_R) = 1{\cdot}311$ Rr $\Delta^{1/3} \div V^2$. (C_F) can be taken from a diagram, such as that in Mr. J. L. Kent's 1915 paper. This notation has the great advantage of showing at a glance the proportion of residuary to frictional resistance, and thus gives a better idea of the efficiency, possibilities, and character of the design than a single (C) alone. The residuary is, after all, the only part over which the naval architect has jurisdiction. This by alteration in form he can vary within wide limits, and it is from this variation that the economic success or failure of the hull design mainly depends. Anything that tends to illuminate this controllable part of the e.h.p. is therefore to be encouraged.

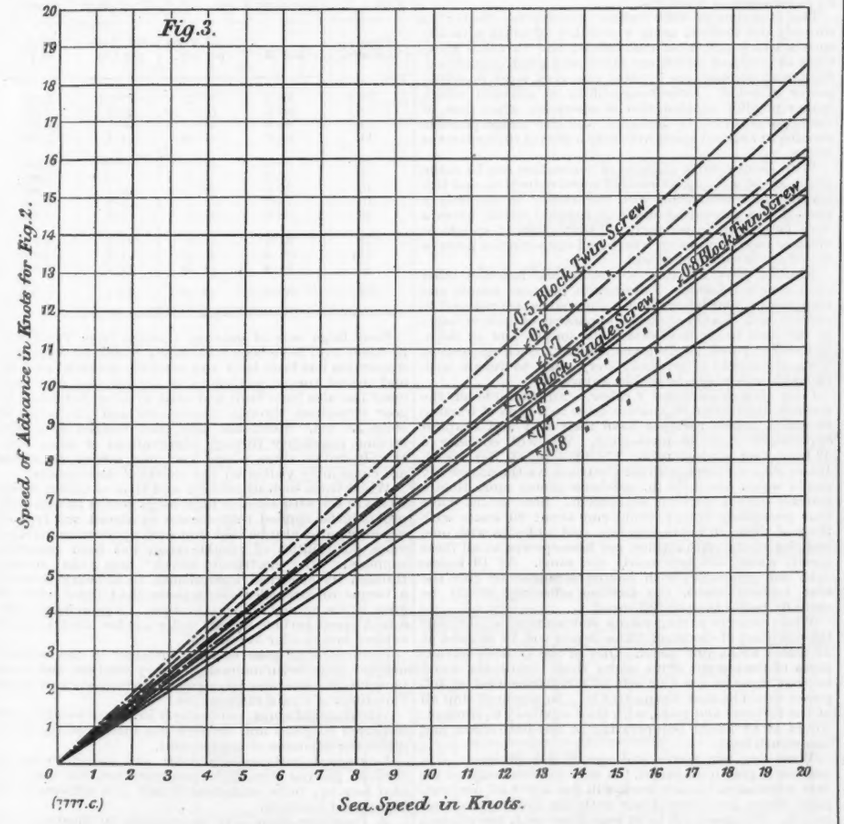
For those who, like the author, are exiled far from experiment tanks, it may still be advisable to check the

Fig. 2.


Revs. per Min.
B. H. P.
Line "A" 0·8 P.R. Propeller at 6 Knots to 8·8 Knots for 1:2 P.R.
Line "B" 0·8 P.R. Propeller at 7 Knots to 10·5 Knots for 1:2 P.R.
Line "C" 0·8 P.R. Propeller at 8 Knots to 12 Knots for 1:2 P.R.
Line "D" 0·8 P.R. Propeller at 9 Knots to 13·4 Knots for 1:2 P.R.
Line "E" 0·8 P.R. Propeller at 10 Knots to 14·7 Knots for 1:2 P.R.
Line "F" 0·8 P.R. Propeller at 11 Knots to 16·2 Knots for 1:2 P.R.

A.	Ansaldo.	F.	Fullagar.	K.	Krupp.	N.P.	Neptune.
B.	Burmeister.	F.M.	Fairbanks-Morse.	M.	M.A.N.	N.L.	Nelseco.
Bol.	Bolinder.	G.	Germania.	M.S.	McIntosh & Seymour.	P.	Polar.
D.	Doxford.	H.	Holeby.	N.	North British.	S.	Sulzer.
						T.	Beardmore-Tosi.
						V.	Vickers.
						W.	Werkspoor.
						W.H.	White.

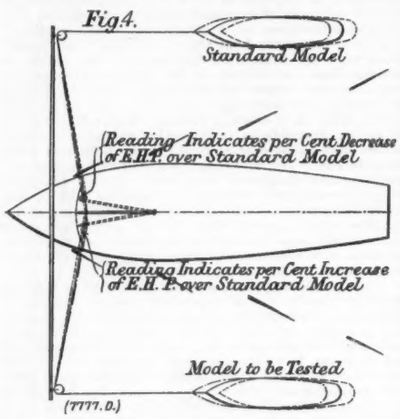
Fig. 3.



(7777.c.)

e.h.p. by actual trial of a model. A convenient arrangement which eliminates the use of dynamometers is to tow against a standard model. This may have been originally obtained from a tank, or else made from lines of which one has the accurate e.h.p. (such as Taylor's standard series). The models of about the same size are towed on opposite sides of a launch, and the towing cords connected to a point on a light pivoted lever (see Fig. 4). The cords and lever (which can be replaced by a third cord if desired) set themselves, of course, to the force diagram existing at the instant. The angle of the lever from the centre line is then a measure of the amount by which the resistance of the new model is greater or less than the known one. The arc swept out by the lever tip can be easily graduated to read in percentages of the e.h.p. Those on the new model side being of course greater, and those on the old model side less than that of the latter. This method is likely to be more accurate than towing against a dynamometer in open water. It largely eliminates the effect of slight unknown currents, which affect the models equally if they are of the same length. Given this, and a constant

Fig 4.


Standard Model
Reading Indicates per Cent Decrease of E.H.P. over Standard Model
Reading Indicates per Cent Increase of E.H.P. over Standard Model
Model to be Tested
(7777.D.)

percentage difference, the current effect is completely eliminated. In any case a 10 per cent. error is not 10 per cent. of the total e.h.p., as when towing against a dynamometer, but 10 per cent. of the percentage difference. If the latter is 5 per cent., the error becomes about ½ per cent., a very different matter.

APPENDIX.

NOTE A.—These efficiency values may seem low, especially for the smaller pitch ratios, when compared with the figures given by Taylor or Froude. But these ultra-fine screws are usually also of small diameter on motor ships. This leads to manufacturing difficulties, and it is hard to maintain the proper pitch at the root, even if there is no overlapping of blades. Probably the efficiencies can be improved on with fairly large diameter screws, though those given may be taken to represent average results.

NOTE B.—Consider three ships of similar length and displacement, and with a common draught of 20 ft. Ship "A" has a C.G. 19 ft. above the keel; "B" 20 ft., and "C" 21 ft. The initial G.M. of ship "B" is 1 ft., and the righting lever at 30 deg. is 0·5 ft. The beam of ship "A" is narrowed to give an initial G.M. of 0·5 ft., and that of ship "C" broadened to give 2 ft. This results in changing the righting arms at 30 deg. to 0·4 ft. and 0·6 ft. respectively when calculated for a C.G. in the load water plane. But at 30 deg. we have to add on 1·0 sin 30 deg. for case "A," and deduct 1·0 sin 30 deg. for case "C." The actual righting arms are therefore 0·9 ft. for ship "A," and 0·1 ft. only for ship "C." Ship "A" is therefore not only comfortable but safe. Ship "C" is less comfortable, and, despite its considerable initial G.M., unsafe in squalls.

THE SIERRA LEONE RAILWAY.—The Sierra Leone Railway is an interesting installation and consists of about 338 miles of 2-ft. 6-in. system, or, including sidings, about 355 miles of track. The main line runs easterly from Freetown to Pendembu, a distance of 227½ miles, which is one of the longest, if not actually the longest, trunk line of this gauge in existence. In 1921, the last year for which official figures have been published the gross receipts of the system were 161,765*l.*, or about 37,400*l.* less than in the previous twelve months, and the deficit in 1921 amounted to 60,444*l.* The main decreases in traffic were in palm kernals and palm oil. The working of the system was recently inquired into by Lieutenant-Colonel F. D. Hammond, C.B.E., D.S.O., whose reports on other African railway systems have been noticed in our columns, and in the report drawn up by this officer the net loss on revenue account for the system, is placed at 149,975*l.* for 1921, while since 1904 the sum of 1,232,431*l.* has been found by the colony to keep the system going. Colonel Hammond considers there has been an inordinate rise in the cost per unit of work done and that the reductions of staff and wages are essential if the system is to be put on a more satisfactory footing. Lieutenant-Colonel Hammond's report, including a map of the system is published by the Crown Agents for the Colonies, London, at the price of 5*s.*

ELECTRIC SHIP PROPULSION.*

By W. L. R. EMMET, Member of Council of the Society of Naval Architects and Marine Engineers, of New York.

History.—The first proposals for the use of electric motors to propel large ships were made long before gearing of a type and speed suitable for this purpose had been developed. The first actual applications to large ships were begun about the same time that the earliest applications of gears were made. The first large ship driven by a turbine with a generator and motors was the United States collier Jupiter. This installation was made by the United States Navy for the purpose of testing the practicability of the method with a view to its possible use in war ships. The writer, who designed this Jupiter equipment, had for a long time been urging the use of electric drive for large battleships in which it seemed to afford many advantages of great value. While the Jupiter was a type of ship in which the advantages of electric drive were relatively small, the equipment was an unqualified success; the fuel economy was much better than in the two sister ships Cyclops and Neptune, one of which was driven by reciprocating engines and the other by geared Parsons turbines. The Jupiter has been in service for ten years and has cost practically nothing for maintenance of machinery.

Experience with the Jupiter convinced many officers of the Navy that this method was desirable for large warships, and the growth of this belief has led to the application of turbo-electric drive to all the large vessels designed by the American Navy within recent years, except some very high-speed, light scout cruisers in which geared turbines were used. The ships completed, or partially completed, in which this method has been used, include seven 30,000-h.p. battleships, four 60,000-h.p. battleships, four 180,000-h.p. battle-cruisers, and one collier.

Advantages.—Much has been published concerning the details of the installations made for the United States Navy, and the advantages which they have sought to afford, and it is only through the study of detail in specific cases that sound ideas can be formed as to relative merits of different kinds of machinery for different ships. In this paper it is intended to show the possibilities of turbo-electric drive application in a type of ship in which it has never been used, namely, a large passenger ship, but before doing so it may be well to review some of its advantages in warships.

The adoption of this method enables us greatly to simplify the turbine, using a plurality of units with the speeds which are most convenient, and to place these units in positions which are safest and most convenient. Reversing turbines are avoided and very large reversing power afforded. Interchangeability is afforded which makes possible continuation of operation when part of the apparatus may be damaged, and also makes possible running at reduced speed with only a part of the apparatus in use.

With electric drive changes of connection can be made which afford a change in ratio of speed reduction, and this feature, in combination with the ability to use only a part of the generating units at reduced speed, gives a very large gain in economy at such reduced speeds as must be used in cruising, where fuel consumption governs the effective radius of action.

Electric drive involves no mechanical function other than simple rotation. Lubrication becomes simple and inexpensive, and labour and maintenance are reduced to a minimum. Large electrical apparatus of such voltages as are used in ships is extremely simple, and in ships, as in other cases, rarely gives trouble. Such apparatus, when damaged, is generally very easy to repair with facilities which are available anywhere.

Case of a High-Speed Cruiser.—An example of the possible application of electric drive to a type of warship in which geared turbines have their best and simplest application may be interesting. We will consider a 32-knot fast cruiser using 120,000-h.p. at full speed. If this ship were equipped for electric drive the machinery would weigh about 10 lb. per horse power more than a suitably-geared turbine equipment. She would have four generating units; could run about 29 knots with three of them, 26 knots with two, and 19 knots with one, and the steam consumption per horse-power at all these speeds would be very nearly the same. At 19 knots, with one generator, with motors arranged to give the best turbine speed, the turbine efficiency would be actually better than at full speed.

With suitable arrangements and voltage adjustment the efficiency of electrical transmission will be as good at 19 knots as at full speed. One of the greatest advantages of the electric drive under these conditions would be that three of the four sets of auxiliaries used at full power would be shut down entirely. In a geared ship all of the turbines and gears, with their auxiliary equipment, would at 19 knots be operating at one-half speed and one-eighth load.

With this low power and speed, the efficiency of a turbine is greatly impaired. A ship turbine designed for best adaptation to such work will use about 52 per cent. more steam per horse-power with the lower speed and power. The gears will be at least 3 per cent. less efficient at this very low load and, in most turbine-driven warships, the auxiliaries at such speeds add 25 per cent. to the steam consumption. Thus, without saving through the use of cruising turbines, we might expect to use 80 per cent. more steam. By the use of cruising turbines this might be reduced to 60 per cent. For comparison we will assume 50 per cent. as the minimum difference that could exist between properly-designed equipment under these conditions. On this assumption the electric ship will use for all purposes, at 19 knots with saturated 250 lb. steam, 0·85 lb. of oil per shaft horse-power-hour. A geared ship with turbines equally well designed could not do better than 1·27 lb. of oil per shaft horse-power-hour.

The difference of weight between the two equipments will be about 535 tons, and this at 19 knots will be compensated for in 3,600 miles of run. And the comparison at lower speeds would be about similar.

Such an electric ship could run at 19 knots from England to the Falkland Islands and, starting with 2,300 tons of oil fuel, would have 200 tons left on arrival. A similar geared ship, filled to equal displacement by carrying 2,835 tons of oil, could not reach at this speed within 700 miles of the distance.

These figures, which are conservative, show that such qualities as are afforded by the electric drive may have great military value, even in a light, high-speed ship where the weight increase of machinery might at first sight be thought prohibitive.

Statements and Proofs.—The comparison which is here made may seem inconsistent with some claims of low-speed economy made by builders of geared ship machinery. It nevertheless agrees with the ascertainable facts, and it should be remembered that turbo-generators are constantly being tested by the manufacturers, while ship turbines without generators are not. Many claims entirely inconsistent with the known possibilities have been made in connection with ship turbines. In all the large naval vessels equipped with electric drive the results shown by careful tests have agreed closely with those predicted and indicated by calculations and by shop tests. And in these we constantly know the results from the electrical readings.

Gear Limitations.—Since the turbine is much more efficient than the reciprocating engine, we are likely to see increased numbers of either geared turbine ships or electric drives. The possibilities of the geared turbine are well understood and need not be much discussed here. It may, however, be well to touch upon certain matters which have been quite generally overlooked in this connection. The writer can speak from some experience in this matter. The General Electric Company has, under his direction, been one of the largest producers of geared turbine ship machinery, having built about 350 ship equipments of this type aggregating over 2,000,000 h.p.

TABLE I.—*Operating Tests, I.J.N. Fuel Ship "Kamoi."*

Speed, in Knots.	R.P.M.	Coal, Tons per day.	Oil, Tons per Day.	Shaft, H.P.
11	86·0	29·29	21·32	2,740
11	86·0	16·9	29·1	2,723
11	86·0	38·4	16·7	2,735
11	86·0	28·84	21·1	2,738
10	78·0	48·8	0·0	1,996
10	78·0	36·7	7·8	1,985
10	78·0	30·7	10·7	1,905
10	78·0	23·7	15·2	1,920
10	78·0	23·6	15·6	1,934
12	94·3	14·9	42·1	4,117
12	94·5	25·15	34·6	3,920
12	94·4	44·45	23·2	3,945
13	102·1	43·85	32·4	5,300

Four large sets of gearing, ranging from 2,000 h.p. to 6,000 h.p., have been elaborately tested for efficiency. Apparatus has been built and carefully observed to show and record torque variations in service, and an equipment has also been built and used to show distortions of gear structures through movements and vibrations of ships at sea. Much has also been learned of geared turbine possibility through observations of many electrically-driven ships where load and torque variations are constantly visible on the electrical instruments.

While from such experience and that of others it can be said that with suitable knowledge geared turbines can probably be applied with success to almost any type of vessel, it must also be said that such application involves more possibilities of trouble than has been generally supposed. An electrically-driven ship has shown, through its electrical instruments, in a heavy seaway, a torque on propeller shafts more than three times as great as the normal full-speed torque. A geared ship with a high-speed turbine would, under similar conditions, be subject to a similar overstrain.

Distortions of gear casings, installed in the solidest manner, have been observed in heavy weather, and these movements have been large enough to indicate very large variations of strain distribution.

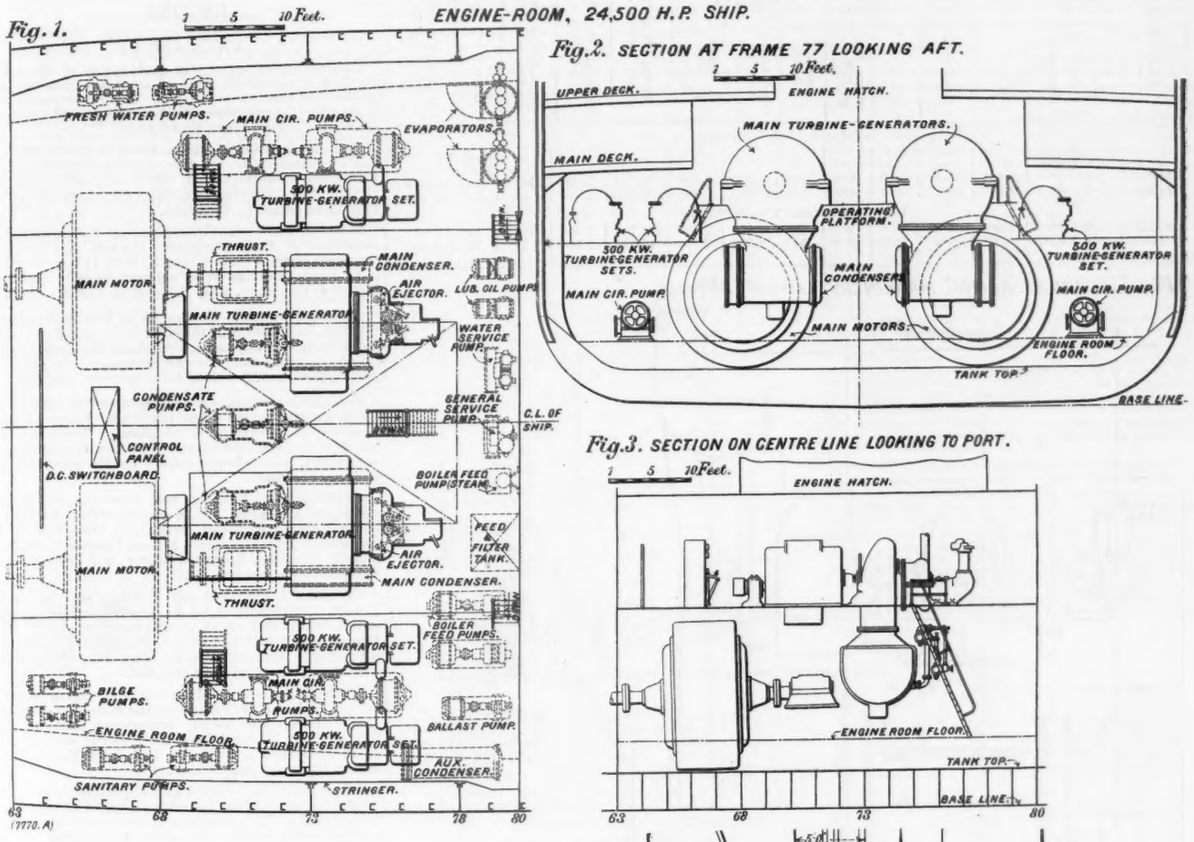
Vibrations of ships, particularly in heavy weather, are imparted to gears and through the inertia of the parts affect the evenness of engagement.

Low-speed turbines are safer and easier to apply through gearing than high-speed turbines, but they are also heavier, more complicated and less efficient than high-speed turbines.

A Passenger Ship.—As an example to illustrate the possibilities of electric drive in a large passenger ship the case of a vessel like the Empress of Canada has been taken. The machinery of this ship was well illustrated in ENGINEERING (London), September 1, 15 and 29, and October 13, 1922, and for comparison an illustration, Fig. 4, from that article, showing an elevation of the machinery space is here given. Drawings, Figs. 1, 2 and 3, are also given, showing possible arrangement of electric drive machinery in such a ship. In these all the machinery is shown in an engine-room made as short as possible. Such an arrangement with generating units

* Paper read at the Spring Meetings of the Institution of Naval Architects, March 22, 1923.

ELECTRIC SHIP PROPULSION.



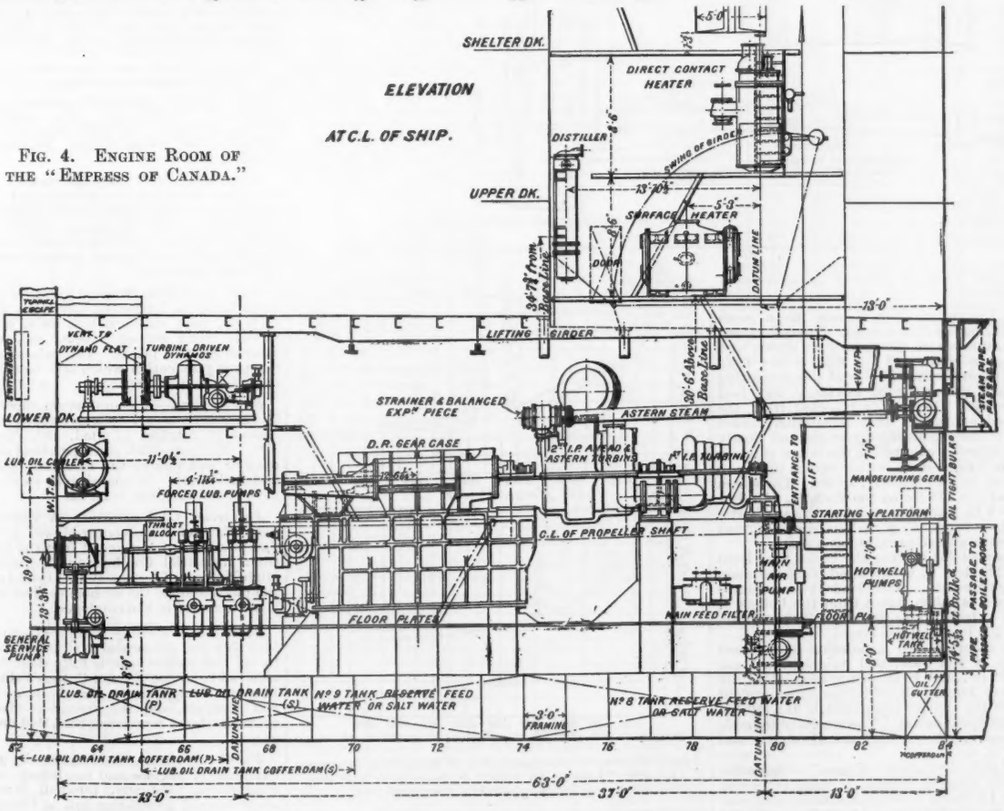


FIG. 4. ENGINE ROOM OF THE "EMPRESS OF CANADA."

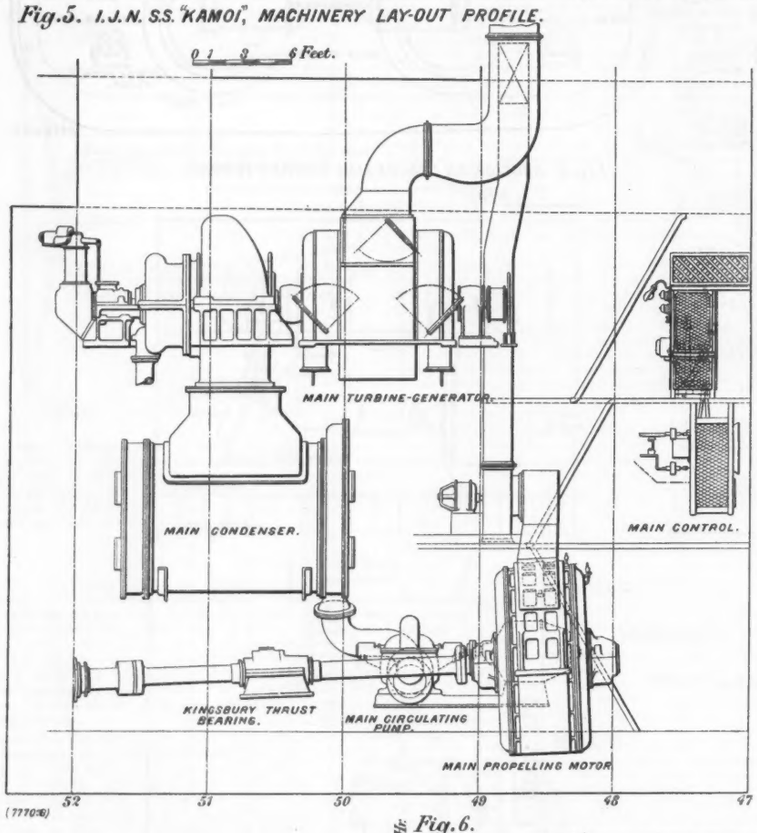
on a higher level is often very desirable, but various other arrangements could be used. Motors could be put in separate spaces nearer the propellers, which might effect some saving in shafts, &c.

Fig. 6 shows by curves the fuel rates for all purposes which should be given by such a ship when operating with two generators and with one. For purposes of comparison and verification of the claims here made a curve and test figures from the fuel ship Kamoi of the Japanese Navy are also given in Fig. 7. The Kamoi, a 9,000-h.p. 15-knot ship, was recently completed by the New York Shipbuilding Company with machinery built by the

TABLE II.

Per Cent. of Full Speed.	Total S.H.P.	Motors. R.P.M.	Motors. Efficiency.	Generators. R.P.M.	Generators. Efficiency.	Main Turbines. Efficiency.	Main Turbines. Steam, Lb. per S.H.P. Hour.	Auxiliaries. Electric Load, Kw.	Auxiliaries. Steam Lb. to Generator Units per Hr.	Auxiliaries. Other Steam, Lb. per Hour.	Steam Lb. Main Units per Hour.	Steam Lb. Make-Up per Hour.	Extracted Steam, per Cent. of Total.	Boiler Efficiency.	Lb. Oil all Purposes, S.H.P. Hour.
TWO GENERATORS. TWO MOTORS.															
			per cent.		per cent.	per cent.								per cent.	
100	24,500	112	97·5	2,464	96·75	76·0	8·8	800	14,000	11,000	229,000	2,500	10½	75	0·811
82	12,200	90	97·1	1,980	96·5	67·0	10·1	620	11,400	8,800	129,500	2,500	9½	75	0·965
ONE GENERATOR. TWO MOTORS.															
82	12,230	90	96·9	1,980	97·0	72·6	9·2	550	11,000	7,800	119,700	2,500	10½	75	0·90
53	3,260	56	95·5	1,232	96·0	52·0	13·2	360	6,500	7,000	46,000	2,500	7¾	75	1·46

Fig. 5. I.J.N. S.S. "KAMOI," MACHINERY LAY-OUT PROFILE.



(7770:6)

General Electric Company. The figures given were obtained by test during her first voyage. The differences between the performances of the Kamoi as shown and of the larger ship, as indicated by Fig. 6, are fully accounted for by the difference in size of the generating units and by more advantageous auxiliary and feed heating arrangements. The results reported from the Kamoi are in good agreement with calculations based upon factory test of her generating apparatus and clearly indicate that the figures predicted for the larger ship are conservative. The figures upon which curves in Fig. 6 are based are given in the Table II, above. The steam conditions assumed are 245 lb. at the throttle, 150 deg. superheat, and 28·5 in. vacuum. Most of the auxiliaries are driven from two condensing turbine direct-current generating units, with a third provided as a spare.

Excess steam needed for heating the boiler feed from 85 deg. F. up to 220 deg. F. is extracted from the main units at 10 lb. gauge pressure. At all loads it was assumed that sufficient steam is taken direct from the boilers to evaporate 27 tons of fresh water per day. This requirement would need 200 lb. of oil per hour.

The apparatus includes two generating units each having a capacity of 9,500 kw. and weighing, without condenser, 195,500 lb., and two motors each of 12,250 s.h.p. and weighing 236,000 lb. The combined weight of these parts with the control equipment is 911,400 lb., or 37·2 lb. per shaft horse-power. The results obtainable with such equipment are shown by Table II, above, and by the curves in Fig. 6.

Trials of the I.J.N. Fuel-Ship "Kamoi."—Operating tests of this boat are given in Table I, on page 414. The builders' trials at 15 knots gave approximate coal consumption (coal alone) first 3 hours, 11,400 lb. per hour; average shaft horse-power, 9,108. Approximate fuel consumption second 3 hours: Oil, 6,792 lb. per hour and coal 1,500 lb. per hour: average shaft horse-power, 9,046. Conditions: 241 lb. steam at throttle, 150 deg. superheat, 28·5 in. vacuum. Feed heated to 197 deg. Through a mistake in opening valves 5 out of 19 nozzles were unnecessarily operated in a throttled condition which must have occasioned a loss of about 2 per cent.

Fig. 6.

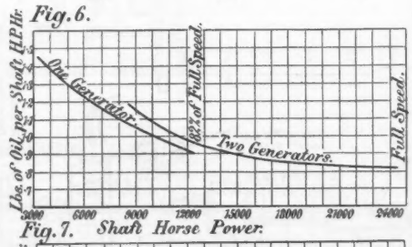
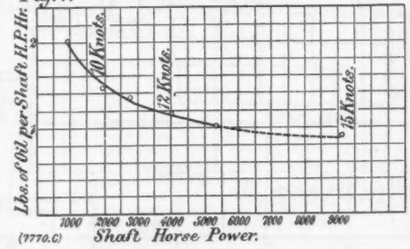


Fig. 7.



(7770.C)

Curve showing oil consumption for all purposes on Japanese fuel-ship "Kamoi" on voyage between New York and Honolulu. All figures obtained from electrical readings.

CATALOGUES.

Electric Locomotives.—An explanation of the advantages of the battery type of electrical shunting locomotive for yard service is given in a catalogue received from the Metropolitan Vickers Electrical Company, Limited, Trafford Park, Manchester

Tanks.—A series of illustrations of very large tanks made by Messrs. Clayton, Son, and Co., Limited, Hunslet, Leeds, for holding gas, oil, water, &c., with a list of oil storage tanks having capacities up to 2,000,000 gallons, have been issued by that firm.

Motor Starters and Controllers.—A 4-page descriptive catalogue of their automatic starters and controllers for direct-current motors ranging from 1½ h.p. to 200 h.p., is to hand from the Westinghouse Electric and Manufacturing Company, East Pittsburgh, U.S.A.

Electric Furnaces.—Catalogues in French, Danish and Spanish, in addition to those formerly issued in German, Norwegian and Japanese, describing the furnaces made by Automatic and Electric Furnaces, Limited, 173, Farringdon-road, London, E.C., are now available.

Fire Extinguishers.—A catalogue of fire extinguishers for hand use comes from the Webb Lamp Company, Limited, Legge-street, Birmingham. These appliances are British made and approved by the leading insurance companies, who allow a rebate on the premium where they are installed.

Oxy-Acetylene Welding and Cutting.—An excellent catalogue and price list of oxy-acetylene welding and cutting plants with gas generators, blowpipes, and all accessories is to hand from Messrs. Charles H. Champion and Co., Limited, Mortlake, Surrey, and Carleton House, Regent-street, London, S.W.

Electric Lighting Set.—A lighting set for country houses, including a 3-b.h.p. paraffin engine, dynamos, switch board and set of accumulators made by Messrs. Drummond Brothers, Limited, Guildford, is described in a catalogue received from the firm. We illustrated and described this set on page 104 *ante*.

Electric Fans.—A number of circulars giving particulars of desk and wall fans made by the Burnley Components, Limited, who also supply component parts to manufacturers, are to hand from their selling agents, Messrs. A. C. Alexandra and Co., 10, Iddesleigh House, Caxton-street, Westminster, London, S.W.

Flour Mills.—A printed and illustrated circular letter of six foolscap pages issued by Messrs. Henry Simon, Limited, 20, Mount-street, Manchester, describes the extension and general replanning and mechanical equipment of the great dock mill at Manchester owned by Messrs. John Jackson and Son, Limited.

Cranes, &c.—A very fine series of steam, hydraulic, electric and hand-driven cranes of all usual types, and also of winding and hauling engines, made by Messrs. Alexander Chaplin and Co., Limited, Helen-street, Govan, Glasgow, has been received from their representative, Mr. James Golder, 10, Broad-street, avenue, London, E.C.

Transformers.—A 14-page quarto pamphlet of instructions for the use of oil-immersed static transformers has been issued by Messrs. Ferranti, Limited, Hollinwood, Lancashire. The pamphlet, which is divided into sections dealing with installation, maintenance, drying out, oil, and markings and connections, is clearly worded and well illustrated.

Bolts, Nuts and Washers.—Messrs. James Wiley and Sons, Limited, Darlaston, have sent us a new catalogue of bolts, nuts, washers, bolt ends, studs, strainers, set screws, wood screws, rivets, &c., with illustrations, dimensions and prices. The catalogue is a useful and compact publication which will be fully appreciated by engineers and others.

Superheaters.—A pamphlet on superheated steam and fuel economy by Mr. Thomas Sugden has reached us from Messrs. T. Sugden, Limited, 180, Fleet-street, London, E.C. The pamphlet gives practical advice, in a simple manner and covers the essential points in an orderly and lucid way. It contains 16 pages of text, in paper covers, and the price is 2*s.* 6*d.*

Pulverised Coal as Fuel.—A catalogue giving some particulars of a pulveriser-blower for reducing coal to fine powder and blowing it into the furnace, is to hand from Industrial Combustion Engineers, Limited, 329, High Holborn, London, W.C. Useful notes on operating the plant and on the economies that may be effected by it are included in the catalogue.

Cutting and Welding Blowpipe.—An outfit including a blowpipe and all accessory tools for cutting and welding by oil fuel and oxygen is fully described in a catalogue received from the Eureka Cutter-Welder Tool Company, Limited, Temple-street, Manchester. The outfit is light and compact, and the process is claimed to be more economical and convenient than that employing acetylene gas.

Petrol Engines.—Ten coloured plates illustrating examples of engines and machinery made by the Aster Engineering Company, Limited, Wembley, Middlesex, show a small generating set, a 100-h.p., eight-cylinder marine engine, a 10-h.p. ship's winch, an arc welding set, and other similar combinations, fixed and portable. The firm manufactures a full range of such plant.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

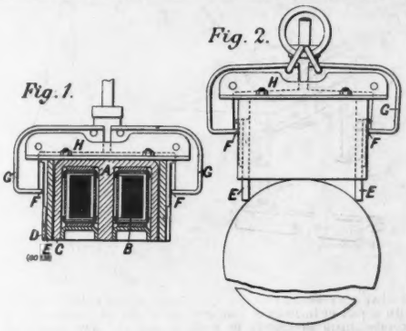
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

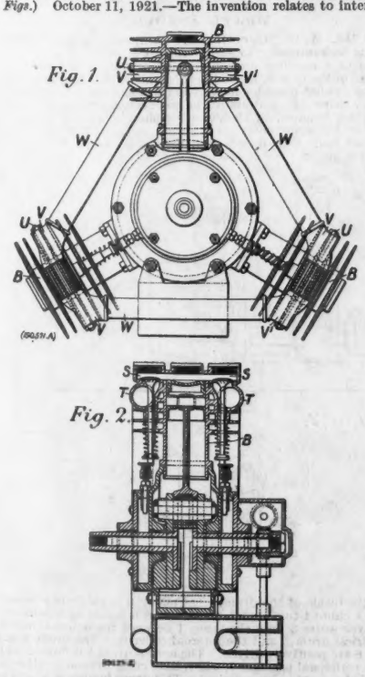
190,739. J. Neale, Oxshott, and J. A. Manners-Smith, London. Electro-Magnets. (5 *Figs.*) June 28, 1921.—The invention relates to electro-magnets for lifting loads. In accordance with the invention, a number of members adapted to act as a pole-piece or pole pieces is, or are, arranged to move relatively to the magnet to adjust itself or themselves to the load, and in the adjusting positions connected with the magnet by means of the lifting tackle. A represents the magnet body, B the electro-magnet windings and C the fixed poles. Adjacent to the fixed poles C the movable poles E are arranged, and slide between



guides D. The movable poles E are constituted of iron plates. The plates E are engaged by the ends F of members G pivoted to a bracket H mounted on the electro-magnet. The members G are connected at their inner ends to the lifting chain so that, on slackening the lifting gear when the magnet has been lowered on to the armature, the movable poles are released and are allowed to take a position in contact with the armature. On the lifting chain being drawn taut, the movable poles are gripped and forced into contact with the fixed poles, causing the magnet to act as a rigid whole and ensuring good contact between the movable and fixed poles. (*Accepted January* 10, 1923.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

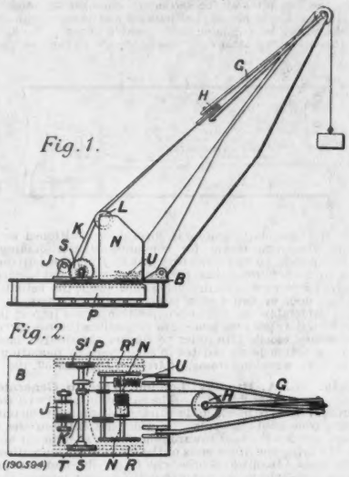
190,571. The S.Y.S. Engineering Company, Limited, Leeds, and W. Riley, Leeds. Internal-Combustion Engines. (2 *Figs.*) October 11, 1921.—The invention relates to internal-



combustion engines of the radial cylinder stationary type. According to the invention, the radial cylinders B are disposed at equal distances apart. Projecting slightly from each valve pocket S is a transverse tubular portion T of the cylinder casting into which is drawn by means of a single central bolt U, two elbows or angular tubes V, V1, each serving to receive a piece of straight tubing W, which serves to conduct the exhaust gases or the petrol vapour, as the case may be, from one cylinder to the other, the tubes on one side of the cylinders conducting the exhaust gases whilst the tubes on the other side convey the petrol vapour, appropriate pipe connections being fitted leading to the carburettor and to the exhaust outlet. (*Accepted December* 30, 1922.)

LIFTING AND HAULING APPLIANCES.

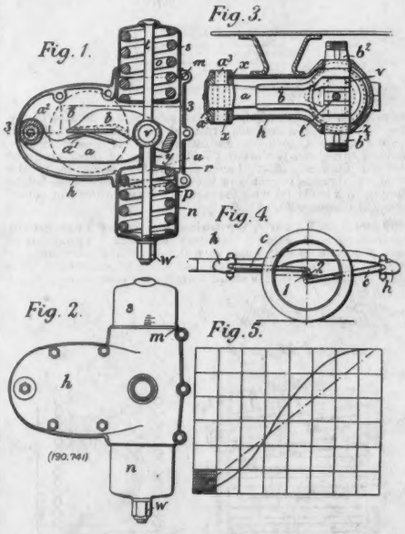
190,594. E. W. Westwood, Leeds, and W. H. Westwood, Leeds. Cranes. (6 *Figs.*) November 1, 1921.—The invention relates to portable luffing jib cranes. According to this invention, the luffing rope or chain K is passed from the luffing drum J over a grooved pulley or sheave L mounted on the crab N, around the pulley or sheave H carried by the jib tie rods G, back over a further pulley on the crab N to connect to the balancing device. The balancing is effected by an adjustable device com-



prising a movable weight P provided with racks R, R1 capable of engaging and being moved by gear wheels S, S1, which are mounted upon and operated by a shaft T to which is connected one end of the luffing rope or chain K. Alternatively a spring, springs or hydraulic ram pump may be employed for controlling the balancing weight. Secured to the platform B is a spring U or other resilient means connected to a drum on the shaft T for controlling the balance weight P, the distance the latter moves being controlled by the spring U. (*Accepted December* 30, 1922.)

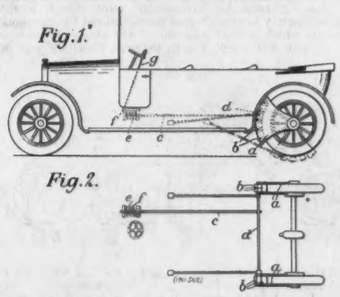
MOTOR ROAD VEHICLES.

190,741. The Monarch Door Controller Company, Limited, Westminster, and A. W. Reeves, Alvechurch. Spring Suspension Arrangements. (10 *Figs.*) June 29, 1921.—The invention has reference to a spring suspension arrangement designed to be mounted between the chassis and an axle of a motor car. According to the construction shown, the spring suspension arrangement comprises a pair of levers *a*, *b* having adjacent rolling or rocking surfaces *a*1, *b*1 of suitable profile. The lever *b* comprises in effect the shorter arm of a lever of the first order, the longer arm *c* of this lever being coupled at its extremity to one of the axles. The other lever *a* is fulcrummed



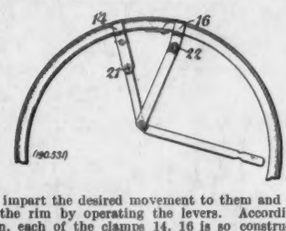
at one extremity *a*2 and adapted at its other or freely movable extremity to cause, through suitable connecting means, compression of a helical spring or springs when moved by the lever *b*. Owing to the rolling lever action, the position of the fulcrum between such levers is constantly varying and the compression of the helical spring or springs becomes thus variable in relation to the vertical movement of the axle 2. The shorter arm of the lever *b*, *c* and the co-acting lever *a* are mounted within a grease-tight casing *h* adapted to be fixed to the chassis of a vehicle and provided with oppositely-arranged openings in which are fixed two tubular holders *m*, *n* containing two oppositely-arranged helical springs *o*, *p*. The spring *p* bears against the outer end of its holder *n* and is provided at its inner end with a cap *r* arranged to slide in the holder. The spring *o* bears at its outer end against a tubular cap *s* arranged to slide in the holder *m*, and at its inner end bears against the inner end of such holder. Extending through the two spring holders, springs, casings and caps are two links *t*, *u*, the inner adjacent ends of which are formed with eyes through which extends transversely a joint pin *v*. The link *t* bears at its outer end against the outer end of the tubular cap *s* and the link *u* is provided at its outer end with an adjusting nut *w* that normally bears against the outer end of the holder *n*. The rolling lever *a* is pivoted at one end, by trunnions *a*3, in bearings *x*, *z* at opposite sides of the casing *h*, its other end being curved and engaged with the joint pin *v* and arranged to act through a tubular distance-piece *y* against the inner cap *r*. The arm *b* of the rolling lever *bc* is provided with a pair of trunnions *b*2, *b*3 mounted in bearings *z* in the casing *h*, and is shaped to embrace laterally the joint pin *v*, the eye portions of the links and the end of the lever *a*. To the trunnions *b*2, *b*3 are fixed, outside the casing, one end of two rods *c*, constituting the longer arm of the lever *bc*, the other ends of which are jointed to a collar 1 on one of the axles 2 of the vehicle. When relative vertical motion takes place between the chassis *k* and the axle 2, the levers *b*, *c* will be turned about their axes and their arms *b* will roll or rock upon the levers *a*, and through the distance-pieces *y*, links *t*, *u* and caps *r*, *s* will compress the springs *o*, *p* to a greater or less extent, depending upon the extent of the relative movement referred to. With this arrangement, a load deflection diagram would show that over the normal working range there will be considerable flexibility of the springs on deflection only, but beyond such range the diagram will show that the spring resistance rapidly increases so as gradually to reduce and ultimately arrest further deflection, this latter action being accomplished with a practically uniform deceleration. This arrangement offers no spring resistance to rebound movements. The diagram will therefore be of a single curve form, that is, similar to the upwardly convex portion of the curve shown in Fig. 5. (*Accepted January* 10, 1923.)

190,502. G. S. Crawford, Bridgeton, Glasgow. Braking or Retarding Motor Cars. (3 *Figs.*) February 20, 1922.—The invention relates particularly to skid brakes of the known type comprising shoes having rollers adapted to contact with both the wheel and the ground when in use. According to the invention, each of the two driving wheels of a vehicle is provided with a braking device of this description, the two braking devices being rigidly secured together so that they act in unison. The braking or retarding device comprises a cage in the form of a shoe *a* carrying a number of rollers *b*. The cage is normally supported in the position indicated by the full lines, Fig. 1, by means of a rod *c* running longitudinally on the vehicle and



engaging with a cross rod *d* to which the shoes *a* at each side of the vehicle are secured so that the devices act in unison. Rod *c* is maintained in position against the action of a spring *e* by means of a catch *f* to which is secured a lever or flexible member *g*. The upper end of the latter may be in the form of a loop through which the chauffeur can slip his arm when driving. Should it be necessary to apply the brake, then, by simply exerting a pull on the member *g*, the catch *f* is released and the rod *c* under the action of the spring *e* moves out of engagement with the cross rod *d*, thereby allowing the shoes *a* to assume the position shown in chain-dotted lines in Fig. 1, both shoes moving in unison. (*Accepted December* 30, 1922.)

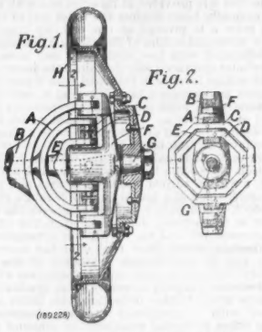
190,531. W. H. Welch, Bishopston, Bristol, and Harvey Frost and Co., Limited, London. Tyre-Engaging Rims. (3 *Figs.*) September 21, 1921.—The invention provides an improved construction of device for manipulating the tyre-engaging rim of vehicle wheels of the type in which the rims are severed at one point in their circumference so that the butting ends can be displaced and made to overlap one another to contract the rim to such an extent that the tyre can readily be removed from the rim. Such devices as hitherto made comprise clamps provided with means to fix them securely on the wheel rim on either side of the gap therein, with levers and links engaging the clamps



so as to impart the desired movement to them and to the two ends of the rim by operating the levers. According to this invention, each of the clamps 14, 16 is so constructed as to engage a substantial length circumferentially of the rim, and each has its pivot pin 21, 22 mounted on it at a point substantially distant from the rim towards the centre thereof, this arrangement providing that in the operation of the device, any force applied to the pivot pin gives a turning effect tending to rock the clamps each about one of its ends, so as to provide an effective binding or frictional grip of the clamp on the rim and thereby prevent any circumferential movement of the clamp on the rim. (*Accepted December* 30, 1922.)

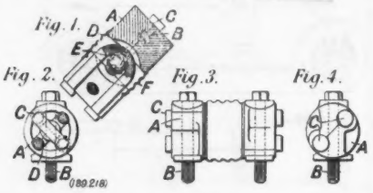
189,228. G. Barker, London. Combined Steering and Driving Wheels. (3 *Figs.*) August 25, 1921.—The invention is for improvements in universal joints and their application to combined steering and driving wheels. According to the invention, the joint comprises a driving member A pivoted at opposite sides to a gimbal ring C about an axis which passes through the axis of rotation of the driving member A, a second gimbal ring D pivoted at opposite sides to the gimbal ring C

to swing about an axis at right angles to the axis of pivoting of the driving member A and which intersects the said axis, and a driven member E which is pivoted to opposite sides of the gimbal ring D about an axis which coincides with that of the pivots for the driving member A when the driving and driven members are in line with each other. When this joint is applied to a road wheel H of a vehicle which is to be driven and also steered, there may be combined with the parts set forth above, a steering member F which spans the joint and is pivoted to



swing about a vertical axis which intersects the rotational axis of the driving member A and the axes of pivoting of the gimbal rings C, D, and a stub shaft G, which is mounted in the steering member F to rotate therein, has its rotational axis coincident with that of the driven member E, projects inwardly from the steering member F and is secured to the driven member E to rotate therewith. The dished road wheel H is secured to the outer end of the stub shaft G with the hollow side towards the joint so that the joint and the steering member both lie within the road wheel. (*Sealed.*)

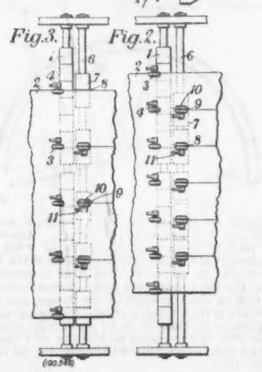
189,218. O. S. Penn, Old Charlton. Track-Laying Vehicles. (7 *Figs.*) August 24, 1921.—The invention relates to chain tracks for track-laying vehicles. According to the invention, each member of the chain track has a U-shaped piece provided with a spherical surface or cup, and a ball is interposed between adjacent spherical surfaces or cups. Each member consists of a block A formed in two parts secured to one another by a screw B which screws into one of the shoes of the track. The two parts of the block A grip between them the legs of a



U-piece C, the ends of which are enlarged so that when the two parts are secured together the U-piece cannot be pulled out of the block. In the bend of the U-piece is formed a spherical surface or cup D, and between the two cups of two adjacent members is inserted a hard ball E, with the result that one member is free to turn about the other in all directions. In order to keep dust or dirt out of the joint between the two members a sleeve F of corrugated rubber tubing or the like may be provided. The extremities of the sleeve may fit into grooves at the adjacent ends in the two blocks. (*Sealed.*)

PRINTING AND ALLIED MACHINERY.

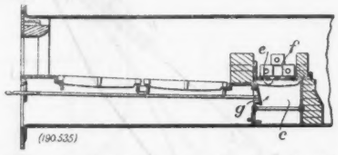
190,548. T. J. Mills, London, and E. T. Morris, London. Printing Machines. (3 *Figs.*) September 24, 1921.—The invention relates to printing machines of the type in which a web of paper is printed and then slit or cut by adjustable slitters into any number of sections or pages of widely differing widths. 1 is a propelling or pulling roller which drives the web of paper 2 to be slit. 3 are pulleys mounted on arms 4



adjustable along and about a shaft 5. The pulleys 3 are faced with resilient material and keep the web 2 in contact with the pulling roller 1. 6 is a shaft having adjustably mounted thereon a number of sleeves 7, each carrying a companion cutter adapted to co-act with an annular cutter 9 on a narrow roller 10. The rollers 10 are mounted on arms 11 adjustable along and about a shaft 12. In Fig. 2 the web 2 is being slit to form six pages by five sets of cutters 9, the web 2 being pressed on to the pulling roller 1 by seven pulleys 3, five of which are in line with the cutters 9, while in Fig. 3 the web is being slit to form four pages by three sets of cutters 9, the other cutters 9, which for clearness have been omitted from the drawing, being moved clear of the web by turning the arms 11 about the shaft 12, the web 2 being pressed on to the pulling roller 1 by five pulleys 3, three of which have been moved into line with the cutters 9, the other pulleys 3, which for clearness have been omitted from the drawing, being moved clear of the web 2 by turning the arms 4 about the shaft 5. (*Accepted December* 30, 1922.)

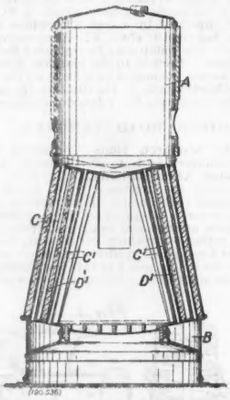
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

190,535. N. D. F. Johnson, Putney, London. Steam Boiler Furnaces. (3 *Figs.*) September 22, 1921.—The invention refers to furnaces which are provided with a secondary grate located behind the ordinary furnace grate, which secondary grate is provided with apertured plates upon which rest blocks of refractory material, and having an air chamber extending entirely beneath the secondary grate and provided with a pivoted flap between the ash pit and the secondary chamber by means of which the passage of air to the chamber and through the apertured plates can be regulated with great accuracy. According to the invention, the means for admitting air to the chamber *c*



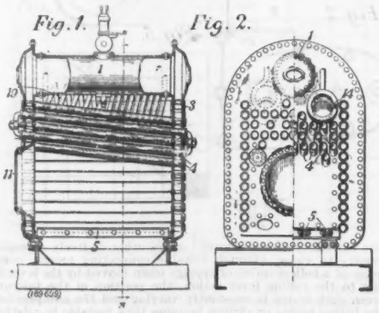
beneath the secondary grate *e* is formed or positioned or has combined therewith means for communicating a shaking or vibratory motion to the refractory blocks *f* for the purpose of clearing dust therefrom, thus preventing fouling and inefficient working. In carrying the invention into effect, the actual air-controlling door or flap *g* or a projection thereon may, in one position, preferably the fully-open position, come into striking contact with the apertured plates *e* or projections thereon carrying the refractory blocks *f*, in order to impart the desired motion thereto, the action being assisted in some cases by mounting the plates in or on a rocking frame. (*Accepted December* 30, 1922.)

190,536. L. A. Hindley, London. Steam Generators. (3 *Figs.*) September 22, 1921.—The invention relates to steam generators of the type in which the top and bottom water chambers A, B are connected by tubes C, which lie between the two chambers and are inclined towards the centre at different angles in order to bring the upper ends of the inner tubes more directly over the furnace than would otherwise be possible and to support the underside of the upper water chamber against internal stress.



According to the invention, there is provided a generator of the type described in which are arranged two groups of tubes C, C1, one group C forming an outer layer of concentrically-mounted tubes and the other C1 comprising an inner group of tubes mounted at different angles. Further, according to the invention, there is provided in the steam generator hereinbefore referred to, a baffle D1 which separates the two groups of tubes. (*Accepted December* 30, 1922.)

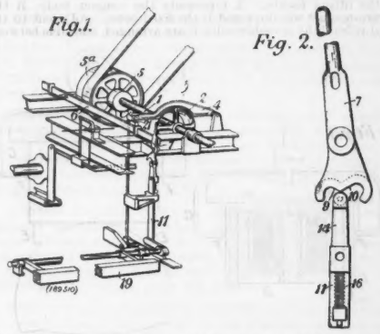
189,699. S. E. Alley, Westminster. Water Tube Steam Generators. (4 *Figs.*) February 10, 1922.—A water-tube steam generator, in accordance with this invention, comprises, in combination, front and rear headers, 3, each constituted of a pair of plates pressed to a shape to form between them a single



water space, an upper horizontal steam and water drum 1 mounted with its ends directly in the inner plates of the headers, and its end walls constituted by the outer plates of the headers, inclined water tubes 4 extending across and above the fire grate 5 and connected at their ends to the headers, a firing opening 11 formed through one of the headers and an outlet or outlets 14 for the products of combustion formed through the other of the headers. Also, in accordance with this invention, there is combined with a water tube steam generator as set forth, a superheater 19 comprising a coil of piping to constitute a flue or duct extending between the headers, encircling at one end the outlet 14 or an outlet for products of combustion in the rear header and having its convolutions adjacent the said outlet in close contact and those remote therefrom widely spaced into which the hot gases and products of combustion pass radially through the widely-spaced convolutions and then flow axially. (*Sealed.*)

TEXTILE MACHINERY.

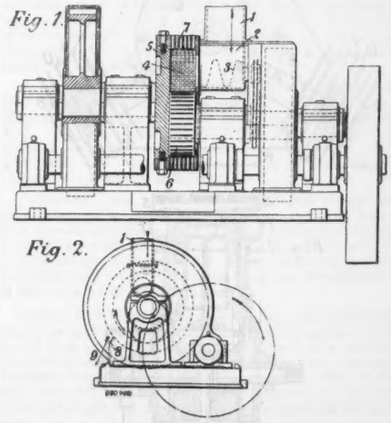
189,510. Brintons, Limited, Kidderminster, and C. C. Brinton, Kidderminster. Loom Stopping and Starting Apparatus. (3 *Figs.*) August 26, 1921.—The invention relates to stopping and starting apparatus for looms and is intended primarily for wide looms used in carpet manufacture. Apparatus, according to the invention, comprises a treadle or operating bar, which extends substantially along the whole front of the loom, and means associated with the treadle or operating bar to stop and start the loom alternately as a result of the same operative movement, as depression of the treadle or operating bar, which latter after each operation returns to a neutral position. The driving shaft 1 carries a brake drum 2 upon which acts a brake shoe carried by a lever 4. The driving shaft also carries fixed and loose pulleys 5, 5*a*. 6 is a bar or lever which operates both the brake and a fork rod operating a belt fork either simultaneously or in quick succession. The bar 6 is provided with inclines for operating the brake and the fork rod. The incline for the brake is indicated at 21, but that for the belt is not shown.



The bar 6 is moved by a lever 7, the lower end of which is formed with a pair of inclines or cam surfaces 9 and 10 adapted to be operated upon alternately by a sliding rod 11. The upper end of the sliding rod 11 is provided with a pivoted finger member 14. The lower end of this finger has a flat surface upon which a coiled spring 16 acts and tends to keep the finger in alignment with the sliding rod 11. The finger 14 is, however, permitted to make an angular movement about its pivot by slight compression of the spring 16. By this means, when the rod 11 is moved upwards to operate upon one of the inclines 9 or 10 of the lever 7, the finger 14 is able to turn slightly on its pivot so as to follow the lever 7 as it turns. When the operation is complete the finger 14 is restored to its position in alignment with the sliding rod 11 by the spring 16. By this time, however, the lever 7 will have been forced over into a position to bring its second incline directly above the finger 14 so that the next operation of the rod 11 will throw the lever 7 into its other position. The bar 11 is associated with a pivoted treadle or operating bar 19 extending along the front of the loom. (*Sealed.*)

MISCELLANEOUS.

190,748. A. W. Sizer, Hessle. Compressing or Moulding Plastic Substances. (3 *Figs.*) August 2, 1921.—The invention relates to a machine for compressing or moulding plastic substances, of the type in which the substance is forced by a rotating roll into radial passages in a cylindrical surface. According to the invention, the material to be compressed or moulded is fed to a space bounded by the outer periphery of a roller or runner and the inner periphery of a drum contacting with it, the material being then forced through radial passages in the peripheral drum to the outside by the relative rolling of the roller



over the inside of the drum. The material is fed from a hopper down a chute 1 to a chamber 2, where it is forced by means of a conveyor worm 3 into the space 4 between the external hollow cylindrical drum 5 and the internal roller 6. The drum 5 and roller 6 are positively driven. The hollow drum 5 is formed with radial peripheral passages 7, which have cross-sections to give the extruded cake the shape desired. This drum further co-operates with a scraper blade 8 (Fig. 2) which allows the extruded cake to fall away in the form of short sections in the direction of the arrow 9. (*Accepted January* 10, 1923.)